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DIVISION OF WATER RESOURCES
EDWARD HYATT, State Engineer

Reports on State Water Plan Prepared Pursuant to Chapter 832, Statutes of 1929

BULLETIN No. 28-A

INDUSTRIAL SURVEY

OF

UPPER SAN FRANCISCO BAY AREA

WITH SPECIAL REFERENCE TO

A SALT WATER BARRIER

Below Confluence of Sacramento and San Joaquin Rivers

An Appendix to Bulletin No. 28

1930

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LETTER OF TRANSMITTAL

Mr. Edward Hyatt,
State Engineer,
Sacramento, California.

Dear Sir: The committee appointed by you to make a study of the industrial development of the upper San Francisco Bay area in relation to a salt water barrier begs leave to submit the report hereto attached.

The committee bases its findings upon an industrial survey prepared by Professor George W. Dowrie, of the Graduate School of Business of Stanford University. Mr. Dowrie has devoted six months of intensive study to this subject. He was assisted by Mr. Oscar A. Anderson, a graduate fellow at Stanford University. Mr. Dowrie has availed himself of the cooperation of your staff and has had access to all the data in your office. He has made free use of the replies to the comprehensive questionnaire which your office sent out to the industries of the area. He has also had recourse to other public documents and has collected independently a large mass of valuable material through interviews and correspondence. Power and water companies, research departments of various organizations, industrial executives, manufactures of cooling equipment, industrial engineers, representatives of government agencies, and numerous other persons who were in a position to throw light upon the problem have cooperated most generously.

The committee has been in close touch with the progress of the study at every stage. Frequent meetings have been held at which the plan of the study and its progress were subjected to careful scrutiny. An exceptionally comprehensive mass of data has been brought together and embodied in this report, which the committee transmits to you with its full approval.

Briefly summarized, the conclusions of the committee are as follows:

We find that the upper San Francisco Bay area affords a most attractive location for industries which require relatively large tracts of land, low cost of transportation, proximity to population centers, and the comparative isolation of a country site. The south shore of Suisan Bay contains, at present, the cheapest solid ground near to deep water in the whole bay region.

In respect to labor supply, power, transportation, accessibility to markets and raw materials, the upper bay region has exceptional advantages of which representatives of the industries now located in the area are well aware. The industrial growth of the area indicates that these advantages are of a substantial character.

Study of such comparable data as were available shows that the rate of growth measured in number of employees, in the size of pay rolls, and in the values created by manufacturing industries has for many years been greater in this region than in the state as a whole, and decidedly greater than the trend for the United States.

The only important disadvantage of the area, as set forth by representatives of the industries located there, has been the encroachment of salt water during the season when the two rivers have too small a flow to repel the salinity invasion.

We do not find that the cost of securing fresh water necessary to carry on industrial processes is a major factor in the budgets of typical industries of the territory. However, to the extent that this cost creates a burden on any important industries in the area, it represents an economic handicap. In addition to this, the salinity consciousness,

which has been permitted to develop, has created a certain psychological handicap which it is highly desirable to dispel.

Building a barrier below the confluence of the Sacramento and San Joaquin rivers, and thus creating a fresh water lake, would doubtless remove both the economic and the psychological effects of the encroachment of salt water. Such a lake would be an attraction to heavy users of fresh water. If, however, the cost of building and maintaining the barrier should result in an unduly heavy tax rate upon property located in the territory, the burdens might well outweigh the advantages and result in a net loss. The influences which lead industries to locate in a particular spot are many and complex. If Suisun Bay could be turned into a fresh water lake at a cost which could reasonably be borne, it would probably tend to stimulate somewhat the industrial growth of the area, but it is not to be expected that there would be any stampede of industries to locate on the shores of the lake. Competing locations would naturally offer counter attractions and would probably match any water rates that might result from the construction of a barrier.

After a careful study of all available data, it appears to the committee that the present generation would have to assume a rather heavy burden for building and maintaining a barrier and that the gains realized in the reduction of water costs would only partially compensate for the expenditures which it would be necessary to make. The committee, therefore, is of the opinion that attention should be focused upon the real needs of the area and upon means of meeting them.

The industries of the upper bay area have definite water problems which need to be solved, and it is entirely appropriate that the cooperation of public authorities should be enlisted in helping to solve these problems. However, their solution does not seem, at present, to justify so elaborate and costly a remedy as a salt water barrier.

The committee recommends, therefore, that serious attention be given to adequate measures for removing the causes of salinity consciousness from which the upper bay area is suffering and for furnishing an adequate supply of fresh water in the most economical way which competent engineers can devise.

Respectfully submitted.

Willard E. Hotchkiss

Dean of Graduate School of Business,
Stanford University, Chairman.

Henry F. Grady

Dean of College of Commerce,
University of California.

Consulting Engineer, San Francisco.

San Francisco, California,
November 19, 1930.

ORGANIZATION

STATE DEPARTMENT OF PUBLIC WORKS

B. B. MEEK.....*Director*
EDWARD HYATT.....*State Engineer*
A. D. EDMONSTON.....*Deputy State Engineer*

ORGANIZATION

on

INDUSTRIAL SURVEY OF UPPER SAN FRANCISCO BAY AREA

This report was prepared by

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Assisted by

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under the direction and supervision of the following committee appointed by the State Engineer:

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CHAPTER 832, STATUTES OF 1929

An act making an appropriation for work of exploration, investigation and preliminary plans in furtherance of a coordinated plan for the conservation, development, and utilization of the water resources of California including the Santa Ana river, Mojave river and all water resources of southern California.

[I object to the item of $450,000.00 in section 1 and reduce the amount to $390,000.00. With this reduction I approve the bill. Dated June 17, 1929. C. C. YOUNG, Governor.]

The people of the State of California do enact as follows:

SECTION 1. Out of any money in the state treasury not otherwise appropriated, the sum of four hundred fifty thousand dollars, or so much thereof as may be necessary, is hereby appropriated to be expended by the state department of public works in accordance with law in conducting work of exploration, investigation and preliminary plans in furtherance of a coordinated plan for the conservation, development and utilization of the water resources of California including the Santa Ana river and its tributaries, the Mojave river and its tributaries, and all other water resources of southern California.

SEC. 2. The department of public works, subject to the other provisions of this act, is empowered to expend any portion of the appropriation herein provided for the purposes of this act, in cooperation with the government of the United States of America or in cooperation with political subdivisions of the State of California; and for the purpose of such cooperation is hereby authorized to draw its claim upon said appropriation in favor of the United States of America or the appropriate agency thereof for the payment of the cost of such portion of said cooperative work as may be determined by the department of public works.

SEC. 3. Upon the sale of any bonds of this state hereafter authorized to be issued to be expended for any one or more of the purposes for which any part of the appropriation herein provided may have been expended, the amount so expended from the appropriation herein provided shall be returned into the general fund of the state treasury out of the proceeds first derived from the sale of said bonds.

FOREWORD

This report is one of a series of bulletins on the State Water Plan issued by the Division of Water Resources pursuant to the provisions of Chapter 832, Statutes of 1929, directing further investigations of the water resources of California. The series includes Bulletins Nos. 25 to 36, inclusive. Bulletin No. 25, "Report to Legislature of 1931 on State Water Plan," is a summary report of the entire investigation.

Prior to the studies carried out under this act, the water resources investigation had been in progress more or less continuously since 1921 under several statutory enactments. The results of the earlier work have been published as Bulletins Nos. 3, 4, 5, 6, 9, 11, 12, 13, 14, 19 and 20 of the former Division of Engineering and Irrigation, Nos. 5, 6 and 7 of the former Division of Water Rights, and Nos. 22 and 24 of the Division of Water Resources.

This report is a part of a general economic investigation of a salt water barrier below the confluence of the Sacramento and San Joaquin rivers. It also is printed as Appendix A in Bulletin 28, which covers the entire subject. It deals with the economic aspects of a barrier as related to present and future industrial development in the upper San Francisco Bay area with particular reference to water supply. The investigation, covering a period of six months, is based in substantial part on 101 replies from a comprehensive questionnaire submitted by the State Engineer to 114 industries located in the upper San Francisco Bay area.

CHAPTER I

THE ECONOMICS OF PLANT LOCATION

Growth and Migration of Industries.

The kinds of factories and business establishments which may be obtained by a given region are of three main types: (1) new home industries; (2) branch plants; (3) industries which have moved bodily. Most of the new industries which rise in an economic region are of the first type; next in order come the branch plants; last come the enterprises which move as a whole.

Some of the factors which lead to the establishment of new factories in a given region are as follows: (1) migration of population, which causes factories to follow people wherever they go; (2) new sources of fuel, power and water, making it profitable to carry on manufacturing at certain localities when motive power is available at attractive rates; (3) new sources of labor; (4) new raw material centers; (5) shifting of markets due to new inventions and demands; (6) development of distribution centers served by land or water transportation, or both.

Industry is sensitive to new developments which have business implications. If new developments bring new opportunities, or if changing conditions call for new industrial adaptations, business enterprises endeavor to take advantage. Modern business is governed largely by the inexorable facts of cost accounting. When unnecessary waste and expense are present, this fact stands out like the proverbial sore thumb. When excessive expense is due to the fact that the location is no longer satisfactory, the industry moves, or puts up branch plants—if it can. The migration of cotton mills to the southern states is partially a result of reading the warnings of cold-blooded cost accounting. This is true also of branch steel plants which have been established in the South Chicago-Gary district. The same may be said of rubber, furniture, automobile and other industries which have come to the Pacific coast in order to be at the seat of a rapidly growing market.

Plant Location as a Problem of Industrial Engineering.

Originally the method of plant location was largely a matter of chance. Many factories were enticed to go to certain communities through the activities of booster clubs which had held out the bait of free sites, tax exemption and other special inducements. This vogue is passing. Appeals are coming to be made upon sound economic grounds. An advertising slogan used by one rapidly growing region is that industries come "Without benefit of bonus." Too often, the results under the old appeal were unhappy, both from the standpoint of the factory and that of the community. A sick business, operating under the handicap of an illogical plant site, is not an asset to any community.

Sometimes an industry is found in a region where transportation facilities are unfavorable, power costs high, and where other disadvantages are present. The reason for its being there, in many cases, is that the originator of the product happened to live in that community, and established the industry there. Sometimes an industry has been

established at a given site out of consideration for one factor, like power or transportation, without due consideration for other plant location factors which should have been taken into account. At best, the old methods were not particularly scientific; the procedure used was haphazard.

Modern problems of plant location are now commonly solved by specialists. They have a scientific technique by which they can arrive at logical conclusions; their methods in arriving at decisions are impartial; they are not unduly influenced by the arguments of local boosters. A common procedure is to draw up a check list of all the plant-location factors which might be pertinent to the success of the industry concerned. With this done, the various prospective areas and sites are evaluated in the light of these factors. The finding of the most logical plant site involves a process of elimination.

Relative Importance of Location Factors.

The value of one factor as compared with another in choosing a plant location depends upon the industry involved and especially upon the particular company in question. The problem of plant location must always be one for individual case study; a sweeping generalization which attempted to rate the relative importance of location factors in a given type of industry would be a misleading guide for a particular firm with specific problems of its own. The men's clothing industry, for example, is often classed as an industry requiring a city site, because: the important market is in the city itself; the class of labor needed may be conveniently secured, and the factory site needed is not large, since clothing manufacture is a multistory type of industry. These criteria may be applicable in a general way but are not to be depended upon for particular cases. Some of the most successful men's clothing plants are located in suburban and even rural districts. The exceptions made to the city-location theory are so many that it would be useless to make out a general rating scheme, showing the relative importance of location factors in a single industry, like men's clothing manufacture. This principle holds true for other industries as well.

However, it may not be amiss to show how an individual expert on plant location may rate the factors for a given factory in a given line of industry. Mr. W. L. Wotherspoon,* in discussing the investigation which led to the selection of a site for a refinery and rolling mill for monel-metal showed how he finally rated the several plant-location factors, but like many other writers on the subject, warned against sweeping generalizations.

	Factor	*Relative weight in per cent*
1.	Fuels	33
2.	Labor	25
3.	Living conditions	10
4.	Power	10
5.	Supplies	6
6.	Climate	5
7.	Transportation	5
8.	Building costs	2
9.	Taxes and laws	2
10.	Site (cost and quality)	1
11.	Water supply	1

* Proceedings of American Society of Mechanical Engineers, December, 1922.

The weighting scheme shows that for the particular factory in question the factor of fuel was thirty-three times as important as such factors as water supply or site-cost and quality, and that such a factor as power was twice as important as the factor of climate. However, these weightings would not necessarily apply in the case of another metal industry, or even another monel-metal mill, which had its own peculiar problems in competition and trade development to face.

A recent industrial survey,* covering sixteen thousand firms in the United States and Canada, shows that the rankings given to location factors vary widely with the section in which the industry in question happens to be located, and, of course, with the type of product manufactured. For example, the summing up of the rankings leaves water supply entirely out of the list of sixteen factors of which mention was made the oftenest, but if all of the participating industries had been heavy users of fresh water, or had all been located in a part of the country where abundant fresh water is not easily procured, water supply would undoubtedly have had a prominent place in the list. This does not mean that in such cases water cost necessarily looms large in the sum total of manufacturing costs, but it does mean that water-using industries can not function normally if they do not have water of suitable quality and in sufficient quantity. In the lists of important location factors given by seven writers † on the subject, selected at random, water is included in all but one case.

A list of items, however, which is ranked on the basis of the number of times it was mentioned in reply to a questionnaire is not wholly without merit, for it does tend to reveal the phases of the subject that are causing the greatest concern. In the survey to which we have just referred the conspicuous place given to markets throughout the replies is indicative of the fact that nowadays disposing of his output is the manufacturer's chief concern. Such a state of affairs augurs well for the development of industries on the Pacific coast for the purpose of serving this important consuming area to better advantage.

In simple plant location problems, there is often a paramount factor which determines the general nature of the site to be selected. Thus, the item of cheap and abundant power is of major importance for abrasive manufacturing. Niagara Falls has become important as a center of production for carborundum and other abrasives, because of cheap electricity. In the case of bulky, moderate-priced products, such as furniture, the plant site must be near as possible to the market served. Canning factories are influenced in their location by the perishability of the raw materials. These examples show how a given factor may be of major importance to one type of industry and of secondary importance to another.

As a general thing, the importance of a given factor is relative to: (1) the nature of the business enterprise concerned, (2) the plus or minus values of the other factors which are peculiar to the region or site being considered. The interplay of considerations from these two points of view calls for an evaluating process that is anything but

* Cooperative survey made by the Civic Development Committee of the National Electric Light Association and the Policyholders' Service Bureau of the Metropolitan Life Insurance Company (1927).

† A. G. Anderson, W. M. Booth, H. S. Colburn, E. B. Powell, G. C. Smith, A. P. Wood and W. L. Wotherspoon.

simple. It is the algebraic sum of combined factors resulting in a minimum of costs that determines the locus point which is suitable for a plant site. The iron and steel industry * is a good example of the way circumstances alter cases in matters of plant location. Considering the diverse factors of (1) market, (2) ore, (3) fuel, which must be reconciled, the following practices are to be noted:

	Distribution of Factors (Material, fuel, market)	*Location of Industry*
(a)	Ore producing, coal producing and market areas approximately coincide.	Industry develops within the common area. Example: Birmingham district, Alabama.
(b)	Ore and coal areas are adjacent or coincide; no important local market.	Industry develops close to or within the common area. Example: Sydney, Nova Scotia; Pueblo district, Colorado.
(c)	Market area coincides with coal area and ore area is accessible.	Ore is drawn to the common territory. Example: Pittsburgh district, ore from Lake Superior district.
(d)	Market area coincides with ore area and coal area is separate.	Coal is drawn to the common area: Steel industry of Italy, obtaining Welsh or Westphalian coal.
(e)	Market lies between coal fields and ore fields with no great distance from route between them.	Industry locates within or close to the market area. Examples: South Chicago-Gary industries using Minnesota ore and West Virginia coal.
(f)	Coal area lies between the ore fields and market region.	Industry develops in or near the coal fields. Example: Steel industry in Saar coal field, Germany.
(g)	Ore area lies between the coal fields and market region.	Industry develops in or near ore fields. Examples: Steel industries at Lake Superior ports, Duluth and Sault Ste. Marie, serving markets of Canada and northwestern United States.

The table suggests how the problem of plant location is affected by the varying combinations of plant-location factors.

Accessibility Versus Proximity.

The ideal in plant location is to have a site that is near the market, and at the source of raw material, fuel, power, water and labor supply. But, as seen in the case of the steel industry, it is not often possible to have all desirable factors centered at one place. This circumstance makes the factor of transportation important. In cane-sugar refining, for example, it is desirable to have a convenient source of raw material, but with cheap oceanic transportation there is no urgent necessity for having proximity of materials. In fact such an enterprise as the California and Hawaiian Sugar Corporation, Limited, which receives its raw sugar from Hawaii, can receive and ship more cheaply at its San Francisco Bay location than it could if located in Hawaii itself. Where good water transportation is to be had, the importance of proximity becomes lessened; in a practical situation it is accessibility, through proper transportation media, that counts.

The difference between accessibility and proximity is to be seen in fresh vegetable and egg marketing. Once the production of vegetables, fruit and eggs required nearness to market, but climatic advantages,

* For details, see the study, "Location Factors in the Iron and Steel Industry," by Richard Hartshorne, pp. 241–252, *Economic Geography*, Vol. IV, No. 3, July, 1928.

fast transportation, and modern refrigeration methods enable distant producers to compete successfully with other producers who are a thousand or even several thousand miles closer to a given market.

Again, the hardwoods of the Orient and the glass-making sand of Belgium are more accessible to various manufacturers in the United States than similar materials found in certain part of the United States itself. Conversely, distant markets may be more accessible, through water transportation, than nearer ones which can not be reached by cheap transportation.

Planned Modification of Factors.

In one sense, man is a creature of his environment, but in another sense he is a maker of it. Industries no longer settle where shipping, transportation and harbor facilities happen to exist. Railroads are now made to come where industries choose to locate, and if harbors are needed they are often built in case a natural one does not already exist. Similarly, if the water factor is not favorable in certain industrial areas while the other factors are, the water is brought to those areas, although the distance may be relatively great.

A cardinal difference between the old New England industrial area and the modern Piedmont-Carolina area is that in the former case industries settled where power happened to be, while in the latter case power is transported to the place where the industries, because of other factors, find it advantageous to locate.

Invention of single purpose machinery, for which operators can be readily trained, makes it unnecessary for plants to locate where there is an abundance of skilled mechanics. In Russia, unskilled urban laborers and even peasants now help to make Ford cars.

The perfection of a new type of manufacturing process emancipated the porcelain-products industry from the requirement of locating where a certain type of skilled labor was to be found. By the acceptance of a new production technique, the porcelain goods manufacturer can choose a plant location independent of the old skilled labor requirement.

All of which means that plant location requires consideration not only of natural advantages, but of those that may be created through new technical processes. When once a site has been selected, buildings constructed, machinery installed, and a corps of employees trained, the die is cast. To avoid mistakes in location, it is necessary to view today's problems in the light of tomorrow's possibilities.

From the General to the Specific in Plant Site Selection.

The necessity for caution has led to circumspect approaches not only in the consideration of technical processes and transportation possibilities, but also in the consideration of regional environments. The question of a specific plant site is determined in view of preliminary questions about the general region considered. In determining upon a site for the new Western Electric Company cable plant, which was to take care of Eastern, Southern and Pacific distribution, the first broad consideration was a choice between a middle western and an Atlantic seaboard location. Each region had its disadvantages, but calculation proved that a seaboard location would have the greater advantages. In turn, a New Jersey location was found to be advantageous over alternative choices in other parts of the Atlantic coast.

Finally, there came the task of choosing between specific sites on a New Jersey water front. By a process of elimination and progression from the general to the particular, the actual site wanted was found at Kearny, New Jersey. The net saving secured, over the original "home-site" in the middle west, amounted to $275,000 per year.*

The circumspect process of going from the general to the particular in selecting plant sites has tended to draw attention to the relative advantages of broad regions, such as the South, the Pacific coast area, the Atlantic coast region, and the Middle West section. On a lesser scale, the localities within regions and areas are considered comparatively.

The Quest for Cooperative Benefits.

Intensity of modern competition has had the parodoxical effect of stimulating cooperative endeavor. The recent regional planning movement for the benefit of community and industry represents an endeavor to temper the wastes of individual effort by the economy of a unified program.

Another manifestation of the desire to secure the benefits of cooperation is to be seen in the development of comprehensively planned "manufacturing districts," offering transportation, power, water supply and other joint services to the several factories. The Central Manufacturing District in Chicago, with its Junction Railway, is a case in point; this single belt line gives all producers within the district a very convenient contact with thirty-nine railways without the disadvantages of delays, worries and costs that would result in dealing with many railways single-handed. The belt-line service is only one of many benefits received. The Bush Terminal of New York also operates on the cooperative benefit principle. As an illustration, manufacturers at the Bush Terminal obtained electric current for light and power at 3.3 cents per kilowatt-hour when other manufacturers paid 7.5 cents per kilowatt-hour. Similarly, insurance rates, freight handling costs and many other items of expense were particularly favorable to the companies enjoying mutual services. Other examples of planned "manufacturing districts" are to be found in such places as Los Angeles, Minneapolis, St. Paul and Kansas City.

A still further indication of desire for associational advantages is to be seen in the rapid development of "metropolitan districts" in which satellite industrial communities tend to develop and cluster about established cities. With a suburban location, a manufacturer may enjoy first-class banking facilities, the services of well-stocked supply houses, the advice of consulting engineers, the benefits of competing railroads, and many other advantages of a city. On the other hand, there are not the disadvantages in the way of an expensive and cramped site, traffic congestion, or expensive water charges. Furthermore, a comprehensive "metropolitan district" offers special inducements to industries which serve as a complement to major industries already established, which tends to give the district as a whole a well-balanced character.

* See "Plant-location Factors of Western Electric Co., Kearny Works," by C. C. Spurling, page 697, *Mechanical Engineering*, Vol. XLIX, No. 6, June, 1927.

All these trends—regional planning, carefully designed manufacturing districts, and more or less spontaneously developed metropolitan districts—reflect the modern desire to capitalize the benefits of cooperation and mutual services.

Intangible Factors of Plant Location.

After tangible factors of plant location have been considered, there still remain the relatively intangible factors. In the last analysis, it is the intangible element that is often the deciding factor which determines whether an industry shall be established in this region or that, in one locality or another. This accounts for surprises when a given community believes it has advantages greater than those of another community and is disappointed to have the prospective industry locate at the other place.

Among the more intangible factors to be considered is that of community and regional morale. With a region divided against itself there is less appeal to prospective industries than that made by a region which is an integrated unit. An integrated region is one that does large-scale planning of a nature that assures the greatest possible present and future economies in industrial operation.

Future economy, especially, is something to ponder in choosing a location. An industry that comes into an area without benefit of comprehensive planning in that area may soon become the victim of unforeseen costs, due to snarled conditions in water supply, transportation, and the like, which wise planning might have forestalled. The problem of regional development is not unlike the problem of municipal development; where comprehensive municipal planning is absent, there is sure to be congestion, confusion and unnecessary expense. Other things being equal, that region or locality is the most promising which has the least criss-crossing of purposes, the least need for overlapping of expenditures for mutual service needs, and the most comprehensively developed natural resources. For such reasons, various writers call attention to "community attitude" as one of the intangible factors to consider in deciding upon a plant location; right attitude is regarded as a form of industry insurance. The United States Census calls attention to momentum as an important factor to consider in plant location. This is another way of saying success breeds success. Risks are good if a community rates well in both tangible and intangible factors, and if the ball has already started rolling in the community's industrial development.

East to West Movement of Industry.

Both cultural and economic progress seem to move from east to west. Western Europe derived her ideas and products from the east, and the American colonies, in their turn, depended upon western Europe for the satisfaction of their cultural wants and for all but the most elementary of their material needs. In like manner, the western states of America have been dependent upon the eastern half of the country for manufactured products and for economic and social leadership.

A study of industrial trends reveals the extent to which the dependence of the west upon the east for manufactured products is lessening. Physical barriers to the industrial development of the west are being removed through developments in chemistry and engineering.

But little progress has been made in removing psychological obstructions which impede the migration of certain industries. Textile manufacturing is an outstanding case in point. Since there is no well-developed center of textile production, experienced manufacturers hesitate to enter the Pacific coast field. Although there appears to be no logical reason why textile mills should not be established on the Pacific coast, as well as in New England and the southeast, capital is hesitant about establishing lone mills in new and unproved territory.

California's growth in the field of heavy industry now affords special opportunities to complementary industries which utilize light forms of labor found as a surplus in heavy industry centers. Because of a plentiful supply of natural gas and oil, and comprehensive electrical developments, the cost of power is relatively low. Furthermore, the mild climate of the Pacific coast reduces plant construction and heating costs.

Taken as a whole, the Pacific coast also has an advantage over the east in respect to proximity to the principal textile raw materials; wool, silk and cotton. Most American wool is produced in the western states and most of the imported wool comes from Australia and New Zealand. Much of the latter passes through California ports to be cleaned and manufactured in the east, after which a part of the finished product is shipped west again. Similarly, the western states are nearest to the source of supply for silk, which is obtained from Japan and China, but the material is transported through western ports to the silk mills of New Jersey and Pennsylvania, the eastern mills having to pay millions of dollars in express, insurance and interest for these land shipments. In respect to cotton, California is adjacent to Arizona and Lower California, which obtain excellent results in cotton growing. Yet, like wool, this raw material goes east to be manufactured into textiles, and a considerable part of the finished product is sent back for western consumption or passes through the west on its way to the Orient. The location of the national style center in the east still constitutes a serious impediment to the development of the textile industry in the west, but among American cities, Hollywood is coming to be recognized as second to New York in its influence upon style trends.

The situation is similar to that which formerly existed in the automobile tire industry, in which the west depended upon the eastern manufactured product. But, with the early inertia overcome in getting plants established in the west, California has now become the second largest tire manufacturing center in the world, providing for western consumption and exportation to the Orient. With psychological difficulties removed, there is no logical reason why other new industries should not be established in the west on an extensive scale.

Western Momentum Under Way.—An index of the momentum of development being experienced by the Pacific states is to be seen in population figures. In the last decade, the geographical group consisting of California, Oregon and Washington, with an increase of 46.4 per cent, proved to be the fastest growing division in the entire United States.

Of the Pacific states, California has had, by far, the most rapid development. The number of inhabitants reported for 1930: viz,

5,642,282, represents a gain of 64.6 per cent over its population of 1920. In fact, 2,215,421 of the Pacific coast's gain of 2,584,741 was made by California, the growth of the Los Angeles area having been especially marked. This exceeds the rate of growth of every other state in the Union. This growth of the west is naturally developing a large consuming area for western products.

The response on the part of business interests to this shift in population is seen in the data on western industrial development. A study of the United States Census of Manufacturers shows that the number of manufacturing establishments in the United States showed an increase of 14.3 per cent from 1914 to 1927. During the same time, the number of manufacturing establishments in California showed an increase of 58.2 per cent—a rate of growth four times that for the United States as a whole. Similarly, for the same period, the value of manufactured products for the United States as a whole increased 121 per cent; while the manufactured products of California increased 280 per cent in value, representing a rate that was 2.3 times that of the nation as a whole. Equally significant is the fact that "Value added to manufacture" showed an increase of 185 per cent for the United States as a whole, during the period from 1914 to 1927, but the increase in California was 334 per cent.

In 1927, the products of industry in the State of California had a value of approximately 2,600 million dollars, of which 1,088 million was added by manufacture. This exceeds the sum of: (1) the value of all crops produced in California in 1927, 479.8 millions; (2) the value of the output of fisheries, 10 millions; (3) the value of all mineral production, 459.6 millions (including metals, stone, natural gas, crude petroleum, clays, salt, sand, etc.), and (4) the value of the output of the forests of California, estimated at 60 millions.*

During its early stage of development, an economic region is concerned principally with the extraction or production of raw materials. The west is still an important source for the products of mines, forests, farms and fisheries, but California, particularly, is fast passing into the industrial stage of its development. Economically speaking, California is approaching its adulthood.

One of the great trade assets of the Pacific coast is its favorable location for Oriental trade. While it is true that Pacific coast trade with Europe has grown faster than that of the United States as a whole, during the past decade, it is probable that Pacific coast trade with Asia and Australasia will greatly exceed European trade in the future.†

For the United States as a whole, the physical volume of foreign trade has increased by about one-half since pre-war days, while the foreign commerce of the Pacific coast has about trebled. The foreign trade of the San Francisco bay region is comparatively well balanced and diversified. Only one item, raw silk, is as high as 15 per cent of the total volume. Three-fourths of the import trade of Seattle consists of raw silk, which raises its import figures to twice the amount of its

* The figure for forest products was obtained from the Forest Handbook of California for 1930. The other data are from the United States Statistical Abstract for 1929.

† Unless otherwise specified, data on foreign trade have been assembled by Dean H. F. Grady, from reports of the Chief of Engineers, United States Army, and from the statistical statements of the San Francisco customs district.

exports. Portland, on the other hand, exports six times as much as it imports, because its principal articles of foreign trade are the lumber, wheat and apples grown in that region. Four-fifths of the water-borne commerce of Los Angeles is petroleum and most of the remainder consists of lumber from the Pacific northwest. Aside from petroleum, flour, lumber and canned goods, the products of Pacific coast mills and factories as yet constitute a relatively insignificant part of our foreign exports. These same mills and factories still fall far short of supplying the large consuming areas about them with manufactured products, so it is not surprising to find that they have little to sell abroad.

As for the possibilities for building up a substantial foreign outlet for coast industries other than the four types mentioned above, political and economic developments in the Far East have a large part to play. The constant turmoil in China, the anti-foreign goods movement in India, the progress of Japan in supplying her own wants are all unfavorable factors so far as expanding our market is concerned. And yet, in spite of them, Pacific trade has increased year by year with respect both to volume and variety of products.

The populations of India and China, particularly, are so huge that an average purchase of one additional dollar's worth of foreign products, per capita, would increase foreign trade by some three-quarters of a billion dollars. Undoubtedly both nations will eventually be industrialized, but in the meantime, with every slight step upward in their very low standards of living, they afford an enormous potential outlet for industrial products. China's present situation surely offers no encouragement to the California exporter, but examples of other nations have shown that when once sufficiently able leadership is found, things right themselves surprisingly fast.

The share of the Oriental market which the Pacific coast states will receive depends upon the ability of manufacturers in this area to compete with those from other industrial areas. If the other location factors, plus skill in management, are sufficiently favorable, the situation of the California industries on the shores of the Pacific should enable them to hold a substantial share of Oriental trade.

However, since foreign trade is only a small percentage of the whole, the chief urge for industrial development for some time to come will be the Pacific coast population that can advantageously be supplied with commodities manufactured in Pacific coast factories and mills.

CHAPTER II

THE ECONOMICS OF PLANT LOCATION APPLIED TO THE SAN FRANCISCO BAY REGION

The territory surrounding San Francisco Bay, including its two upper arms—San Pablo and Suisun bays—and the navigable portions of the Sacramento and San Joaquin rivers, in many respects constitutes an economic unit. There exists a strong interdependence among the several areas which constitute this region. Its important common interests and problems call for a well-articulated regional program rather than for displays of local rivalry.

San Francisco is the financial capital of the region and the location of the executive officers of most of the large enterprises operating within its boundaries. San Francisco, Oakland, Sacramento and Stockton are the principal wholesale and retail distributing centers of the area, and the whole area looks to them for the more highly specialized types of personal service.

The Labor Situation.

The bay region as a whole, with its population of considerably over a million, is well supplied with industrial workers. Wage rates, however, are relatively high, as will be seen from the data which follow. On the other hand, it would be necessary to have comparable data concerning relative efficiency of labor before assuming that higher money wages result in higher labor cost.

According to a United States Department of Labor Survey * as of July 1, 1929, the average hourly entrance wage rates in cents, for common labor, were as follows for industries of the type which prevail in this region:

Industry	*United States*	*New England*	*Middle Atlantic*	*East-North-Central*	*West-North-Central*	*South Atlantic*	*East-South-Central*	*Pacific*
Iron, steel	42.5	41.8	41.8	43.6	36.8	35.4	28.5	48.6
Leather	42.2	50.0	44.2	43.4	---	34.6	33.7	52.6
Paper	44.0	47.4	41.6	44.4	39.2	36.4	27.1	43.3
Petroleum	45.7	---	46.3	51.4	50.0	40.3	32.5	57.4
Cement	37.8	---	42.5	38.0	35.7	---	31.0	47.2
Foundries	39.8	39.6	42.0	43.5	40.3	27.5	32.6	51.4
Meat packing	42.0	44.8	41.9	42.0	42.1	40.0	---	41.9
Average for 13 industries surveyed	43.7	48.0	46.4	48.4	41.8	30.2	26.8	47.9

A comparison of average weekly pay envelopes in identical industries for the same week of April, 1929, taken from the same source of information, shows the relationship between regions as it exists when the pay of more highly skilled factory workers is averaged in with the type covered by the preceding table.

East-North-Central	$32.15
Pacific	28.40
Middle Atlantic	27.50
New England	25.30
South Atlantic	20.15

* Monthly Labor Review, October, 1929, p. 172.

It will be noted that while wage scales on the Pacific coast are higher than the average for the country, they are lower in both instances than the prevailing rates in the great industrial area comprised in the east–north–central states.*

Transportation.

The area is served directly by the main lines of three transcontinental railroad systems, the Western Pacific, the Southern Pacific and the Santa Fe. The Northwestern Pacific serves the territory north from Sausalito to Eureka. Not all parts of the bay area have equally good facilities and equally prompt service, but a common rate schedule applies over the whole bay region. Some important parts of the area have lacked the stimulus which competing rail lines afford, but the Interstate Commerce Commission seems disposed to sanction the entrance of competing lines wherever the situation seems to warrant.

The bay area, in common with the rest of California, has an unusually complete network of improved motor highways. The opportunity thus afforded for the use of trucks has made possible delivery direct to the purchaser, or, if rail or water shipping is necessary, delivery is made by truck to the point of shipment.

The whole of the United States is so thoroughly covered with main lines of railroad that no section possesses any great advantage over another in that respect. Rail hauls, however, compared with water shipments, are expensive and, in the case of articles which have large bulk and weight in proportion to their value, railway charges can soon become prohibitive. It is for this reason that the greatest economic development tends to occur where water transportation is available.

In addition to its foreign, intercoastal and coast-wise commerce, the bay area has a large volume of local traffic along its own shores and on the two important rivers and the smaller streams tributary to it.

The following data, compiled by Dean H. F. Grady,† show in approximate figures the relative importance of the water-borne commerce of the port of San Francisco from the standpoint of destination:

To foreign countries	$1,500,000 daily average
To Hawaii	250,000 daily average
To Atlantic Coast of United States	330,000 daily average
Coastwise	2,800,000 daily average
Local	2,000,000 daily average

In his annual report for 1929, the Chief of Engineers, United States Army, gives the total water-borne commerce of the four leading Pacific coast ports as follows:

	Short tons	*Rank among U. S. ports*	*Value*	*Rank among U. S. ports*
San Francisco	41,019,000	2d	$2,257,747,000	2d
Los Angeles	25,696,000	4th	956,702,000	4th
Seattle	8,907,000	11th	773,747,000	7th
Portland	9,165,000	10th	343,220,000	13th

Much is said about the advantage of plant location on deep water where ocean "freighters" can come directly to the company's dock, but relatively few concerns in the San Francisco Bay area have any

* In this group are Illinois, Indiana, Ohio, Michigan and Wisconsin.
† See footnote on page 19.

such volume of shipments to or from points on a given steamship route as to warrant a call for an ocean vessel. Even the very smallest of enterprises, however, finds it profitable to utilize the smaller bay and river craft in bringing in raw materials and sending out their finished products. Ocean steamship lines are keenly competitive, and whenever a sufficient volume of merchandise is forthcoming from any point in the bay area on a sufficiently deep channel there will be no lack of such service.

Foreign Commerce.

We have already indicated in the preceding chapter the volume of commerce of the San Francisco customs district. The following table shows the principal items of export and import, arranged in order of total value.*

Exports	*Imports*
Canned and dried fruits	Raw silk
Refined mineral oils	Green coffee
Barley	Copra
Raw cotton	Burlap
Automobiles	Chinese wood, nut, or tung oil
Canned fish	Raw sugar
Canned milk	Coconut oil
Asphalt	Tea
Redwood lumber	Print paper
Cigarettes	Tin
Canned vegetables	Bananas
Rice	Crab meat
Flour	

The port of San Francisco ships relatively little for other areas. Nine-tenths of the volume of products imported are consumed in northern and central California, and the same proportion of exports are produced there. As noted in the preceding chapter, an examination of products imported and exported indicates how little California has developed general manufactures such as constitute the list of exports from major eastern ports, and likewise how few manufactures are received from foreign countries by water.

The following are the best foreign customers of this shipping area, according to the data for 1929:*

United Kingdom	39	million dollars
Japan	24	million dollars
Philippines	16	million dollars
Canada	7.6	million dollars
Australia	27	million dollars
China	16	million dollars
New Zealand	8.4	million dollars

The remaining amount, 74 million dollars, was distributed among the other countries of the world. It can be readily seen that the Orient and Australasia constitute an important part of the foreign market for the San Francisco Bay region.

That adequate competition exists for the business which the bay region offers is evidenced by the following statement of the shipping facilities afforded on the routes indicated.†

* Annual (1929) Statistical Statement of Customs District of San Francisco.
† 1930 issue, Year Book of "San Francisco Business," p. 69.

To Australasia	8 lines
Around the world	5 lines
To the Orient and Hawaii	15 lines
To Europe	17 lines
To Central and South America	13 lines
Intercoastal	21 lines
Coastwise	22 lines

Fuel and Power.

Fuel oil is supplied by barge from the four large refineries in the upper bay. A slight advantage in cost is had by the upper bay industries because of the shorter haul. The price of fuel oil per barrel in this area compares with prices elsewhere as follows: *

San Francisco Bay	$0.89
Portland and Seattle	1.10
Los Angeles (El Segundo)	0.85
St. Louis	1.26
Chicago	$1.36–1.40
Detroit	1.57
Pittsburgh	1.68–1.73
New York	1.15
Boston	1.15

At 89 cents per barrel, fuel oil costs 14.7 cents per million British thermal units.

Natural gas from the oil fields is available to the industries of the bay region. A minimum rate of 14 cents per thousand cubic feet is made to industries for that part of the flow of gas which is in excess of domestic and other similar requirements. At this rate the cost would be 12.2 cents per million British thermal units. Natural gas is being made available to certain industrial centers in the east, but comparable cost data can not be had. However, by reducing the prevailing cost of coal to a British thermal unit basis, a comparison of fuel costs may be obtained, although to make gas and coal costs truly comparable an industry would have to add to its coal cost the expense for handling, storage and labor charge for stoking and removing ashes.

The following table shows in British thermal units the cost of coal in certain cities (without the added costs indicated above), the cost of fuel oil in the San Francisco Bay area, and the cost of natural gas in the same area.†

	Cost per million British thermal units for Fuel oil	*for Natural gas*	*for Coal*
San Francisco Bay	14.7 cents	12.2 cents	---
Chicago	22.8 cents	---	14.3 cents
Birmingham	---	---	13.0 cents
Atlanta	---	---	16.0 cents
St. Louis	20.8 cents	---	10.5 cents
Cleveland	---	---	12.2 cents
Buffalo	---	---	13.9 cents
Pittsburgh	28.2 cents	---	9.7 cents
Baltimore	---	---	17.4 cents

Electric power lines serve all parts of the bay region from a common "hookup," and at the same scale of prices. The following table, compiled from charts prepared by the statistical department of the Pacific

* Figures furnished by the Standard Oil Company of California.
† Information regarding gas, coal and power rates furnished by the Pacific Gas and Electric Company.

Gas and Electric Company, shows how prices of electric current to industrial users compare for different centers:

COST OF ELECTRIC POWER TO INDUSTRIAL USERS

Based on uniform load factor and use of 400 hours per month

City or locality	Size of installation		
	100 horsepower (cost in mills)	500 horsepower (cost in mills)	1,000 horsepower (cost in mills)
St. Louis	24.8	24.8	10.0
Detroit	23.2	21.5	13.0
Chicago	17.7	12.7	11.0
Pittsburgh, Pennsylvania	16.6	13.5	9.5
Los Angeles (municipal)	13.6	11.1	8.
San Francisco	12.8	11.1	9.
Southern California (outside Los Angeles)	16.6	10.0	9.

Raw Materials and Markets.

Since these are primarily problems which concern specific industries and do not lend themselves to much generalization, their treatment will be taken up in detail only in connection with the plants in the upper bay area. We need only note here that cheap water transportation has compensated for the great distance by land from certain raw materials, and that the surrounding territory has supplied the rest. Likewise, adequate markets are afforded (1) by the presence in the western states of nearly a tenth of the nation's population, and (2) by the fully developed ocean transportation system which we have already described.

Sites.

The question of the cheapness and quality of industrial sites, like that of markets and raw materials, can best be dealt with in connection with specific areas. The bay with its several arms and tributaries offers a shore line more than four hundred miles in total extent, so that the possibilities for expansion along a water front, so far as mere space is concerned, are practically unlimited. In addition there are in the nine counties within a radius of forty-eight miles from San Francisco many thousands of acres of additional land offering potential industrial sites.

Comparison of the Several Areas in the Bay Region.

Although the chief concern of this study is with the area which borders upon Carquinez Strait and Suisun Bay, a brief comparative survey of the other principal industrial areas in the region will place the study in proper perspective.

Before taking up the several areas in their turn, it will be of interest to note the distribution of the water-borne commerce, in 1929, as an index of present utilization by the bay region of its several shipping points:*

	Short tons	*Value*
San Francisco (City)	14,400,000	$1,613,000,000
Oakland	5,800,000	327,000,000
Richmond	5,800,000	119,000,000
San Pablo Bay	4,700,000	82,000,000
Suisun Bay	4,900,000	64,000,000
Carquinez Strait	9,700,000	228,000,000
Other points	1,800,000	54,000,000

* See footnote on page 19.

West Shore of San Francisco Bay.—San Francisco, proper, has been zoned for light, heavy and unrestricted industry. From Fort Mason to China Basin, however, the whole water front is fully occupied. While some fairly large sites are still available back from the water front, they are attractive to the type of industry which can afford to pay prevailing prices because of certain other peculiarly favorable conditions. Reclamation work * at Islais Creek, authorized by the state, will make available some 280 acres which should sell for $1.50 to $3 per square foot. According to local authorities land at that price is destined for purposes of distribution and multi-story manufacturing plants.†

An extensive area south of Hunter's Point, near to a deep channel in the bay, could be made available for industries at from 50 cents to a dollar per square foot.

The San Francisco city district is second in the state in value of industrial output.‡ but its industries have selected their locations largely because of proximity to the local market. The existence of deep water at San Francisco has fostered industries like coffee, spice and chocolate processing, which derive their products from abroad and distribute them through the channels available in a large urban center.

South San Francisco, already the seat of a number of industrial plants of the heavier type, has ample acreage for large-sized plants at moderate cost. Since it lacks direct access to deep water, a 19,000-foot channel is contemplated, which would tend to increase greatly the value of the sites adjacent to it. South San Francisco, although a separate municipality, is closely connected by rail, street car and highway with San Francisco, and is in the same terminal rate area.

In San Mateo County below South San Francisco, a large area of marsh and of dry land extends back from the bay to the cities and towns built along the Southern Pacific line. Seven thousand acres of dry land are already available for industrial uses. Between South San Francisco and Port San Francisco, just north of Redwood City, further land could be made suitable for industries at from $2,500 to $5,000 per acre. In many cases, a firm foundation would have to be secured through the use of piling.

At Port San Francisco, an area of about 3500 acres, and perhaps 640 acres additional, is available for development. An engineer's report states that "the first unit will provide 100 acres with 500 lineal feet on thirty feet of water." Clay and shale underlie this land at a depth of 30 to 40 feet. At Redwood City, definite plans are under way for a deep water barge canal, together with 2800 feet of docks, cold storage facilities and a turning basin.

Port San Jose, at the extreme lower end of the bay, is still another deep water outlet for the products of the Santa Clara and adjacent valleys which is being given serious consideration.

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* It should be borne in mind in reading this chapter of the report that on substantially all lands which have been filled from dredged materials the costs of foundations will be higher than where the structures are built on natural soil. This added cost has to be weighed against the advantages of having a plant located on deep water.

† These data for the West Bay District furnished by the Industrial Department of the San Francisco Chamber of Commerce and Mr. F. T. Letchfield, Industrial Engineer, San Francisco.

‡ U. S. Census of manufactures, 1927.

The whole territory on the west side of the bay north of San Jose has been served directly by but one railroad line, the Southern Pacific, but access is had across the bay to the other trunk lines, the same rates to outside points applying on both sides of the bay. The examiner for the Interstate Commerce Commission has recommended to the Commission that the Western Pacific be allowed to build a line into San Francisco, crossing the bay near Redwood City. This added line, with the Bayshore Highway and two transbay bridges nearby should add considerably to the attractiveness of the whole San Mateo County industrial area. A deep channel extends down the bay as far as Dumbarton Bridge, but access to it from the industries on the shore would have to be provided by dredging channels.

San Mateo and Santa Clara counties are so admirably adapted for residential purposes that there exists a conflict of interests. Owners of attractive homes and extensive estates resist encroachment of industries. This situation is bound to place a limit on industrial development in these counties.

Fresh water for industrial use in the San Mateo country area can be obtained from private wells or from the municipal supply. Several large industrial wells are in use at South San Francisco, but the constantly increasing drain upon the limited supply of underground water on the Peninsula does not offer much encouragement for additional water supplies from this source.

*East Bay Communities.**—On the east side of the bay, below Alameda, the wide salt marshes lying between the deep water and solid ground make utilization of the land for industrial purposes a matter of the somewhat distant future.

In Alameda and Oakland, land values are high, and in some sections of the former natural foundations are none too good. The typical price of $30,000 to $40,000 for available acreage is high for plants which require a considerable amount of land and find no marked advantage in being situated within an urban district. Oakland, like San Francisco, will probably appeal chiefly to the multi-story type of establishment whose product can absorb a relatively high land cost.

A large interest operating under the name of the Berkeley Waterfront Company, has obtained control of much of the shore line from the Key Route Pier to Richmond, and will undoubtedly develop industrial sites for the types of industry which require large acreage and, at the same time, should be located relatively close to large centers of population, and be readily accessible to deep water facilities.

At Richmond, additional high class industrial property is being made available along a channel thirty-two feet in depth. Attractive sites thus will be provided for terminals and manufacturing plants requiring deep water transportation facilities.

A large potential industrial area exists between Point San Pablo and Pinole Point. This would require bulkheading and filling, and would only be made available to take care of special types of plants requiring large areas free from obstruction, easy accessibility to deep water, and good labor supply.

* Information on the East Bay situation was obtained from Mr. F. D. Parr of the Parr Terminal Company, San Francisco.

Some wells are in use in the plants of east bay industries, but the new east bay municipal supply from the Mokelumne River is the principal source of fresh water.

The Upper Bay.—Stockton * has recently assumed a new importance as a potential industrial area. A twenty-six-foot channel which is now under construction through the upper part of Suisun Bay and the San Joaquin River will enable ocean vessels to dock at the Stockton terminals. As a result, the considerable tonnage of grain, canned fruits and vegetables, dried fruits, and some manufactured products which heretofore has had to be shipped by rail or river to a San Francisco Bay port from the central valley area can be loaded on vessels at Stockton. In like manner, inbound shipments of lumber, wood pulp, and general merchandise can be brought directly to Stockton. The present industries, for the most part, are the type which serve the local area (farm machinery, containers, boats) or process its products (canneries). Ample fresh water can be had in the river, with little trouble from salinity at that distance from the Golden Gate—about ninety miles. The city is served by all three transcontinental lines. Much land is available for industries, but that which is best located is low-lying and would have to be protected by levees.† Industrial growth in the near future, as at present, will be devoted largely to serving the surrounding territory and processing its products.

Sacramento‡ is some twelve miles farther from the ocean than Stockton. Sacramento also serves the great central valleys. It is located on two of the transcontinental lines and connects with the third at Stockton. It has a ten-foot river channel to Suisun Bay.§ The water in the river at Sacramento is soft and free from salinity. Abundant industrial land is available, although, as in the case of Stockton, the best situated land would have to be protected from inundation. Flour mills, fruit and vegetable canneries and a large can factory constitute the principal industries. The rest are mostly of the smaller local variety. A ship canal to Sacramento has been under consideration for a long time, but now that the Stockton project has become a reality, the facilities of that port should, for some time to come, prove adequate to serve the territory tributary to both cities. There is no immediate likelihood of a considerable influx of industries which are not closely related to the local area.

The following data, from the Market Data Handbook of the United States Department of Commerce, 1929, show the status of manufacturing in the several cities of the bay region in 1927:

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* Document 554, House of Representatives, 68th Congress, 1st Session, "San Joaquin River and Stockton Channel, California," 1925.

† C. E. Grunsky, Report on Sacramento Deep Water Ship Canal, 1925, p. 61.

‡ C. E. Grunsky, Report on Sacramento Deep Water Ship Canal, 1925, esp. pp. 1–61.

§ The old nine-foot channel is in process of being deepened to ten feet.

	Number of plants	Number of wage earners	Thousands of dollars			
			Wages	Cost of materials	Value added	Value of product
San Francisco	2,092	41,909	$61,134	$237,642	$192,086	$429,728
Oakland-Berkeley-Richmond	866	23,235	35,031	167,549	94,227	261,776
Sacramento	197	6,359	8,377	25,210	17,759	42,969
Stockton	131	3,001	4,240	13,178	10,718	23,895
Upper Bay [1]	58	14,450	22,000	215,000	70,000	285,000

[1]Data include all major basic industries below Antioch and above Richmond approximately 80 per cent being from replies to State Engineer's questionnaire, 15 per cent from Byron Times, 12th Development Edition, and 5 per cent estimated.

From Point Pinole to Antioch on the south shore of Carquinez Strait and Suisun Bay, and at Vallejo and Benicia on the north shore, are located the group of industries which are the special concern of this study. Here inexpensive land is nearer to deep water than at any other point in the bay region. Large tracts have been available away from centers of population where fumes from industrial processes and the hazards of explosive manufacture create a minimum of concern, although this situation is changing with the growth of the upper bay communities. No handicap of city-street rights of way, or building restrictions hampers the laying out of the plant.

From Crockett to Martinez there is little land readily available between the hills, the railway lines and the water. To the east of Martinez, a stretch of lowland has been purchased for reclamation in the general neighborhood of Point Edith.

From this proposed development to Antioch, a considerable acreage of solid land is still available—the typical price is about $7,000 an acre for water front property and about $2,000 for that a half a mile or so farther back.* The Stockton deepwater project will add to the attractiveness of this area for industrial purposes.

At Pittsburg, particularly, wells have been used to supply fresh water when the water in the river becomes brackish. Other industries supplement their own river supplies with the filtered and treated river supply of the California Water Service Company.

The Southern Pacific and Santa Fe railroads traverse the Contra Costa side of the bay, and the Western Pacific, through its ownership and use of the Sacramento Northern, provides the shipping services of a third transcontinental system. The north shore of Suisun Bay and the strait is served by the Southern Pacific and the Western Pacific. The Mare Island Navy Yard at Vallejo, the government arsenal at Benicia, and some private industrial enterprises in these two cities constitute the present development. Port Sacramento, between Vallejo and Benicia, is being projected as a further extension of north shore industrial and shipping activity.

Because of the wide area of marsh land and shallow water which prevails along the north shore of Suisun Bay, it will probably not be developed industrially for some years to come.

The types of industry which exist in the upper bay area have proceeded to build up their own labor force with a favorable turnover rate and comparative freedom from disturbances. The typical wage of

* Data obtained from a company specializing in upper bay industrial sites.

unskilled male labor seems to be 50 cents an hour. Italians, Portuguese, Mexicans, with some American laborers, furnish the common labor supply. Skilled labor averages from 75 cents to a dollar or more an hour.*

The upper bay is, on the whole, better adapted to making products intended for distribution by steamer and rail over a wide area, than providing the populations of the large urban centers with the things they consume directly. However, so populous a region with so great a number and variety of industries, commercial firms and farms, offers no mean outlet for the products of an industrial district, even though the more basic type of industry predominates.

Markets and Raw Material Sources of Upper Bay Industries.

Few of the raw materials used by upper bay producers, aside from the products handled by canneries, originate within the area. The presence of many of them in California and other western states and the easy accessibility of the rest, because of low water transportation costs, has prevented the raw material factor from becoming an impediment to the industrial growth of the upper bay area.

Raw Material Sources.—Specifically, according to the statements received from the industries themselves, the problem of securing raw materials for the several types of industry in the upper bay is met as follows:

Oil refineries:
1. By pipe lines from San Joaquin Valley.
2. By oil steamers from southern California.

Lumber products:
Rail and steamer, or combination of the two, from Oregon, Washington and California.

Cane sugar refinery:
Steamer from plantations in Hawaiian Islands.

Steel mills:
1. Local scrap.
2. Pig iron from Utah.
3. Eastern and foreign water-borne shipments.

Rubber mills:
Rubber—Straits Settlements; Cotton—southern California and San Joaquin Valley.

Chemical companies, including sprays, insecticides, etc.:
California, Japan, Washington, Texas, Belgium.

Canneries—Vegetable and fruit:
Nearby ranches.

* Data with respect to the upper bay area have been obtained almost wholly from a questionnaire prepared and sent to the industries of the area by the office of the State Engineer. A brief summary of the contents, given at the end of this report, evidences the comprehensiveness and painstaking character of this search for pertinent facts concerning the industrial situation and water problems of the area. For some six months after the questionnaires were placed in the hands of the industries, much "follow-up" work had to be done by the State Engineer's staff, in order that the fullest possible information might be secured. Short of a prohibitively expensive plant-by-plant investigation by a staff of experts, the data are probably the most complete and reliable that could be obtained.

Canneries—Fish:
San Joaquin and Sacramento rivers and upper bay, and trawlers from Pacific Ocean.

Explosives:
Chile, Texas, Pacific coast states.

Ship yards:
Pacific coast and eastern United States.

Dairy products:
Nearby ranches.

Asphalt products:
Largely California, some from Trinidad, the Orient and eastern United States.

Brick works:
Clay at site.

Beverages:
Local mineral springs.

Grain cleaning, warehousing, etc.:
Local valleys.

Mills—Flour and feed:
California—mostly. Some from Washington, Oregon, Idaho and the east.

Sand, gravel, cements, etc.:
Local river and bay bottoms.

Paper boxes:
1. Paper from east and mills in north.
2. Board from Stockton, Antioch and Washington.
3. Straw, scrap paper and rags from local sources and wood pulp from northern mills.

Tannery:
Western states, Argentina, Mexico.

As has been noted, the above information was obtained from the replies to the questionnaire sent to the several industries by the State Engineer's office. No complaint was made by any of the industries to the effect that they were badly located with respect to raw material supplies.

Markets for Upper Bay Products.—The following statement compiled from the State Engineer's questionnaire shows the market for the products of upper bay industries:

Oil refineries:
North and South America, Europe and the Far East.

Lumber product manufacturers:
Mill work—mostly local. Some wood products sent to east and middle west.

Sugar refinery:
Thirty-five states of the United States.

Steel mill:
Eleven western states and the Orient.

Rubber products mill:
World wide market.

Chemical plants:
Eleven western states, a small amount to the middle west and foreign countries.

Canneries:
The whole world.

Explosive plants:
The Pacific states, South America and the Far East.

Ship yards:
The Pacific coast; United States Navy.

Asphalt product plant:
Eleven western states, Alaska, Mexico, the Orient.

Brick works and other building materials:
The bay region.

Beverage plant:
The bay and delta areas.

Flour and feed mills:
Poultry and stock feeds are for the most part sold locally; the Sonoma, Marin and Napa County chicken ranches comprise a large market. Flour is sold in California and the Orient.

Box Factories:
Local poultry and fruit interests require a large quantity of wooden boxes. Paper boxes have a world-wide market.

Tanneries:
Leather is sold on the coast and in thirty foreign countries.

So far as most points in the west are concerned, and those foreign and eastern markets which can be reached by water, the upper bay region has no difficulty in meeting competition, provided other factors are favorable. Two or three firms, however, which cater to San Francisco and Oakland trade, expressed dissatisfaction with the upper bay as a location for their industries.

Dominant Location Factors in the Upper Bay Area.

The following table indicates the number of times the industries listed the several location factors directly or by implication in replying to the State Engineer's question as to why they chose a location in the upper bay:

1.	Water transportation facilities	63
2.	Rail transportation facilities	53
3.	Good highways	51
4.	Close to the market for a particular product	43
5.	Raw materials at hand or cheaply obtained	34
6.	Existence of a suitable building	15
7.	Satisfactory labor force	10
8.	Near San Francisco and Oakland	10
9.	Ample cheap fresh water at time of locating	10
10.	Comparative isolation	6
11.	Climate	5
12.	Adequate site at low cost	3
13.	Recognized center of the industry	2
14.	Favorable topography	2

When asked to point out the special advantages and disadvantages experienced in their present locations, the various groups stressed the following:

I. Fruit and vegetable canners and pickling works—

Special advantages:
1. Nearness to a perishable raw material.
2. Access by rail, highway, steamer, to foreign, intercoastal and bay markets.

Special disadvantages:
None specified.

II. Lumber and wood products—

Special advantages:
1. Raw material by water at low transportation cost.
2. Large consumption area reached by rail, water, highway.

Special disadvantage:
1. Too long a haul to its two large customer areas, San Francisco and Oakland.

III. Rubber products—

Special advantages:
1. Crude rubber brought to dock from Orient.
2. Fabric from California cotton.

Special disadvantage:
1. Very heavy water user for process. Product adversely affected by salty water pumped from bay during salinity period.

IV. Chemicals—

Special advantages:
1. Raw materials come from Asia and western United States—transported cheaply.
2. Fumes blow away from cities.

Special disadvantages:
1. Only cheap water now available is in the bay and rivers. Cooling apparatus used deteriorates at abnormal rate because of saltiness of its supply during dry season.
2. Certain processes not undertaken because of lack of cheap fresh water supply during salinity period.

V. Oil refineries—

Special advantages:
1. Accessibility of foreign, western and local consuming territory.
2. Head of valley pipe lines.

Special disadvantages:
1. Type of apparatus used wears out faster when cooling water becomes salty.
2. Fresh water bought from public supply systems is too costly.

VI. Fish canners—

Special advantage:
1. Raw material from two rivers and the ocean.

Special disadvantages:
None specified.

VII. Ship building—

Special advantage:
1. Can float vessels directly into deep water.

Special disadvantages:
None specified.

VIII. Creamery—

Special advantage:
1. Adjacent to ranches.

Special disadvantage:
None specified.

IX. Powder plants—

Special advantage:
1. Isolation of sites.

Special disadvantage:
1. Type of cooling apparatus used is destroyed relatively fast because cooling water is salty.

X. Copper smelting and refining—

Special advantages:
1. Ore transported to plant at satisfactory cost.
2. Prevailing winds carry fumes away from cities.

Special disadvantage:
1. When river water used in process becomes salty it injures product.

XI. Paper and fibre products—

Special advantage:
None specified.

Special disadvantage:
None specified.

XII. Iron and steel products—

Special advantage:
1. Large supply of scrap metal in populous area. New iron produced in Utah and transported at satisfactory cost.

Special disadvantage:
1. Obtain present water supply from wells. Dependability for future expanded program, questionable. River water is cheaper and softer, but is salty in dry season and turbid during flood period.

XIII. Cane sugar refining—

Special advantage:

1. Deep water from plantations to plant.

Special disadvantage:

1. Heavy user of water of very low chlorine content. Has obtained such supply at great expense heretofore. (Is now developing a new supply in the hope of obtaining a considerable reduction in water cost.)

Summary of Location Advantages of the San Francisco Bay Region as a Whole.

1. Nearest of the manufacturing areas of the west to the west's geographical population center.
2. Large consuming population within its own limits and in adjacent valleys.
3. Lack of extremes in temperature.
4. Location in extensive fruit and vegetable canning region favorable for canneries, can companies, tin mills, makers of food machinery and implements used in planting and cultivating raw product.
5. Served by a network of railway lines.
6. Motor highway system comprehensive and up-to-date.
7. Ocean steamship lines to forty foreign countries and to eastern, southern and Pacific coast ports of the United States.
8. Labor supply adequate and comparatively free from labor troubles in plants.
9. Power—electric, fuel oil, natural gas—at rates which compare favorably with other industrial areas.
10. Navigation between points in the bay and into Sacramento and San Joaquin rivers.
11. Accessibility to the San Francisco money market, one of the largest in the United States.
12. Numerous plant locations with bay water available for industrial uses.

Obstacles to the Industrial Development of the San Francisco Bay Region.

1. Municipal water supplies are being provided at such great expense that a price of 24 to 30 cents per thousand gallons is exacted in most instances. This, no heavy user of fresh water can afford to pay unless the other location factors are sufficiently favorable to wipe out the handicap.
2. Unlike most important industrial centers of the east and south, the bay region proper,* contains no stream or lake along which an industry can locate and pump an abundant supply of fresh water the year around.
3. Private wells, which furnish an abundant supply of fresh water in some regions, are used by a few industries in the bay region, but this source of fresh water can not be relied upon to any great extent.

* Excludes locations on the two rivers above the line of salinity encroachment.

Summary of Outstanding Location Advantages Afforded by the Upper San Francisco Bay Area.

1. Availability of large acreage of level sites on solid ground and deep water.
2. Low cost of sites compared with other developed bay areas.
3. Adapted to one-floor type of heavy industry which covers large acreage and whose main markets call for deep water transportation. Will not attract so readily those which can pay large rate for space in a city.
4. Equal availability, with other parts of the region in respect to raw materials from California or neighboring states, or those brought in by way of ocean vessels.
5. Relative isolation for industries that are obnoxious or dangerous to city populations.
6. Four of the largest oil refineries in California are located in this area, which assures a plentiful supply of fuel oil with a negligible transportation cost.
7. Natural gas and electric power are available to industries at as low rates as elsewhere in this region.
8. Labor supply and cost are favorable.
9. Raw material for canneries, such as the asparagus of the delta, the fruit from the two great valleys, and fish from the rivers, is close at hand.

The obstacles noted in the case of the bay region as a whole apply with equal force to the upper bay.

CHAPTER III

WATER AS A PLANT LOCATION FACTOR—IN GENERAL AND IN THE AREAS UNDER SPECIAL CONSIDERATION

Most authorities on plant location include water as a factor to be considered in the establishment of a factory. It is an item that is frequently weighed with such other factors as market, raw materials, labor, transportation, power and fuel.

From an industrial point of view, there are three important aspects of the water situation, viz, its quantity, its quality, and its cost. Some of the industries which find the quantity of water an important item for manufacturing purposes are:

1. Oil refineries
2. Iron and steel industries
3. Meat packing plants
4. Soap and soap compound factories
5. Sugar refineries
6. Tanning establishments
7. Paper manufacturing industries
8. Textile industries
9. Cement mills
10. Explosive manufacturing plants
11. Rubber product industries
12. Plants manufacturing chemicals and allied products
13. Industrial power stations
14. Food canning and preserving industries
15. Dyeing industries
16. Beverage production plants
17. Ice making plants
18. Paint and varnish plants
19. Salt refineries
20. Gelatinous product industries

Cooling and condensing call for especially large quantities of water, either salty or fresh. Fresh water is used also for boiler purposes, for washing, cleaning, filtration processes, boiling or treating products, distillation, steaming, etc.

Quality of water available is of primary importance in many industries. Textile mills demand a great volume of soft water free from iron and sediment. Rayon mills, for example, will not tolerate such elements as iron, magnesium and calcium, which discolor goods or give hardness to the water. To remove undesirable elements in the water usually involves considerable expense and therefore various kinds of textile mills consider softness and purity of water as one of the major considerations of plant location. Suitable water has been one of several factors which have attracted rayon and other mills to the southeastern states. Canneries need a water under a hardness of 170 parts per million, a water that is clean, sanitary and low in organic nitrogen. Power producers, oil refineries and steel plants need (1) a good quality of boiler water, free from sediment and oil, fresh and soft, and (2) large quantities of either salty or fresh water for cooling and condensing.

The Pacific Coast Situation.

The salvation of the Pacific coast states is the oceanic wind which precipitates its moisture for the benefit of the western mountain slopes. If the prevailing wind were from the opposite direction the west coast would be barren indeed. Mountains like the Sierra Nevadas, with their long western slopes, serve as a condenser for the precipitation of water from the moist west winds. Properly utilized, the fresh water afforded is ample for a large coastal civilization.

Taken as a whole, the surface waters of the Pacific slope vary greatly in quality. In respect to hardness, the water is softest in the north and hardest in the south. In some parts of California water is relatively hard, but Mokelumne River water, for example, which is the source of the east bay municipal supply in San Francisco-Oakland region, has a hardness of only 40 parts per million, which constitutes a softness that is comparable with water found in such low-average states as Washington, Oregon and New York.

Much of the water used by municipalities, ranches and industries in California is pumped from underground. This extensive practice has led to a serious falling of the water table in many parts of the state. The wise utilization of water resources is becoming a major problem in California. Surface storage is an important means for providing against shortage of water.

The Lower San Francisco Bay Area Situation.

The east and west sides of the lower San Francisco Bay have both had to take steps to forestall water famine. The cities on the east side of the San Francisco Bay have formed the East Bay Municipal Utility District for the purpose of bringing water some ninety miles from the Mokelumne River to reservoirs at Oakland and Berkeley.

San Francisco is incurring the heavy expense of bringing in the Hetch Hetchy water supply from the Tuolumne River.

Smaller towns and various industries about the lower San Francisco Bay are depending largely upon wells and somewhat upon local surface water as a source of supply. Lack of water is retarding the development of desirable residential sites on the foothills in the region. A further exploitation of underground waters and some tying in with the large municipal supply projects will have to be done, if near future needs outside of the large cities are to be met.

The Upper San Francisco Bay Area Situation.

The region about the San Pablo and Suisun bays is much less densely populated than the lower bay area, hence the need for an abundant supply of fresh water has been less urgent. The public water supply companies to be found about the upper bay have thus far been able to get along with local sources of supply and have not as yet been driven to seek distant ones. The water companies, sources of water obtained, annual consumption, and cost of water to large users are as follows:

Organization	Source of water	Annual demand in million gallons	Cost to large users in cents per thousand gallons
Antioch Municipal Water Works	San Joaquin River	212	[1]9.3
Benicia Water Company	Local streams	94	44.0
California Water Service Corporation	Sacramento River and wells	1,105	23.3
Hercules Water Company	Wells and East Bay Municipal supply	94	26.7
Pittsburg Municipal Water Works	Wells	200	16.7
Martinez Municipal Water Works	California Water Service Corporation	213	34.7
Vallejo Municipal Water Works	Creeks in Napa and Solano Counties	570	26.3

[1] Within city limits of Antioch.

It can be seen from a comparison of this table with that on page 60 that the cost of water to large users from public supplies is high compared with prices which prevail in the United States east of the Rockies and in the Pacific northwest. This is partly due to the fact that the water-supply companies have encountered heavy costs, for which customers must pay.

The California Water Service Corporation has spent one and a half million dollars at Clyde in developing a pumping project and reservoir to yield three and a half million gallons a day. An ultimate yield of eight million gallons is being planned. The point of intake is at Mallard Slough. The company sells water to Martinez and Concord and covers the territory from Pinole on the west to Bay Point on the east. What the company will do in its future development program is contingent upon other developments in the region and upon its success in securing the patronage of large users of water. This same method of procuring fresh water for this area is susceptible of much further development.

All told, with respect to water supply, the upper bay region is operating at an economic disadvantage. This is the inevitable result when a single coordinated plan of development is lacking. The following illustrations show the need of careful regional planning with respect to water supply: The California and Hawaiian Sugar Refining Corporation, Limited, has been bringing water to its plant at Crockett by means of barges, which at times must go many miles up-stream to reach a source of fresh water supply. During recent years, this source has been supplemented from July to December, inclusive, by a Marin County supply taken aboard barges at San Quentin. In an attempt to alleviate its difficulties, wells were also dug in the hope that industrial water could be found, but there was no success. A nine-mile pipe line from San Pablo to Crockett was projected, but the supply was found to be too uncertain. The corporation believes that its water problem has now been solved by a pipe line being constructed to bring water from wells in Napa Valley.

The Hercules Powder Company at one time received its water from Pinole Creek. This source of supply ran out and, as an emergency measure, water had to be secured from Spring Valley in drums. Many wells were drilled also, and a special six-inch pipe was connected to the East Bay Water Company's system, but during the peak of its business the powder company was still hampered by lack of adequate water supply. During the war the supply of munitions from this area was seriously curtailed by the shortage of fresh water. In Solano County, during the war, soldiers had to be rationed as to water because of shortage. At the present time, such of the industries of Contra Costa County as must have a considerable supply of fresh water for boiler and process, depend upon wells and public supplies as a supplementary source when the volume of river flow is at its minimum and the salt encroachment is present.

Salt Water Difficulties.

The encroachment of salt water upon a fresh water area raises a problem in connection with both domestic and industrial water supply. One reason is that saline water can not be treated and made fresh, in

large quantities, without prohibitive expense; it is particularly hard to remove dissolved salt from water.

Even when some new source of fresh water supply is found, the economic troubles in trying to surmount the water question do not necessarily come to an end. The new supply secured may be more or less temporary in nature, and still newer sources must be sought after the temporary source becomes unsuitable or deficient. Companies which turn from bay water to wells as a recourse in the time of salt water difficulty are often compelled to find new wells as old wells become useless. In their reply to the questionnaire, the representatives of a very large water-consuming industry in the upper bay area stated:

> Depreciation on wells is placed at 10 per cent as the wells get salty in time and have to be abandoned.

Another large user states his case in the following manner:

> Water from our private wells has been used for boiler water during summer seasons until the summer of 1929 when hardness increased to 82 grains per gallon, making it unfit for boiler use. Hardness was approximately 40 grains in 1921.

Another manufacturer, who uses river water for some purposes and well water for others, says:

> We have had three wells turn salt since 1924.

Another manufacturer makes the following statement:

> Since 1924 this company has been without water in summer time from which it was possible to manufacture. In 1924 it cost $5,000 to haul water for ———.* Under present conditions we could not afford to manufacture this article in summer during the last four or five years.

When asked as to what financial loss, if any, they have incurred from the salinity conditions in the upper bay and rivers, several typical industries replied as follows:

> A. Depreciation of plant equipment is double that with fresh water. Have losses due to the eating away of condenser tubes, condenser boxes, piping, and concrete by hot salt water. Salt water after it is heated by condensers and coolers eats away both concrete and steel. This would be reduced 50 per cent by the use of fresh water.
>
> B. Apparatus is designed for the use of salt water.
>
> C. Have been forced to use thicker walls for condensers, which helps to meet the corrosion problem, but cuts down the efficiency of equipment. Many other adaptations in equipment are being made. Increased cost of manufactured products and plant operation is 5 per cent. Costs in plant maintenance and depreciation of plant equipment are 300 per cent above normal with fresh water available. Costs in 1929 in excess of costs in 1920 directly chargeable to salt water conditions amounted to $81,000.
>
> D. Financial loss due to increased salinity of river:
> Plant operation, $40,000 per year.
> Depreciation of plant equipment, $3,600 per year.
> Depreciation above normal with fresh water is about 200 per cent.

* Name of product omitted. Confidential information.

E. Increased depreciation above normal for various types of equipment is 100 to 400 per cent.

F. As close as we can figure it, the financial loss to this company due to salt water is in excess of $20,000 per year.

G. Depreciation of equipment for condenser and cooling purposes—four times that resulting from fresh water.

H. Mechanical roasters and power house condensers deteriorate very rapidly by reason of salt water.

I. Abnormal cost due to excessive depreciation of plant equipment and added expenses in plant maintenance is 35 per cent above normal.

J. High salinity does not result in abnormal depreciation of condenser and cooling equipment because necessary expenditure for equipment to resist salt water corrosion has been made.

K. Depreciation rate for heated water equipment is 30 per cent above normal.

L. Abnormal depreciation rate of condenser and cooling equipment is $500 per year for this company.

These cases show that the water in the upper bay can be employed for certain industrial uses the year around, but that (1) deterioration is increased if the type of cooling equipment used is not adapted to this most economical source of water, and (2) that a cheaper fresh water supply should be developed for boiler and process use.

The Relative Importance of Water to the Upper Bay Industries.

The upper bay area, by chance or design, contains an unusually large proportion of heavy water using industries. According to their own statements, they were not attracted to the area, *primarily* by the supply of fresh water which the upper bay afforded during the greater part of the year, but this factor seems to have been given considerable weight by some of them. The canneries, chemical plants, iron and steel mills, oil refineries, powder works, paper company and rubber mill, which dominate the upper bay industrial set-up, all use large amounts of water for process or cooling, or both. In no case does the water cost constitute more than a small fraction of the value of the product.* It might still be true, however, that those industries which have to meet keen competition from plants located on plentiful supplies of fresh water, other manufacturing costs being equal, would find that the water situation in the upper bay would put them under a severe handicap.

None of the industries in the area have moved away because of the water situation, and four new enterprises of considerable size—The Johns-Manville Company, the tinplate mill at the United States Steel Products plants, the Shell Products Company, and the Stockton Brick Company, near Pittsburg—have located there since the salinity condition became troublesome. However, such a complication of factors is involved in the location of a new plant that one is hardly safe in attributing to salinity conditions the failure of still other enterprises to locate in the upper bay area. Furthermore, a representative from the bay region states that he recently engaged in six weeks of conferences with eastern officials of plants who contemplated establishing Pacific coast branches.† He reports that the industries in question were attracted by the market, labor and transportation facilities of the upper bay district, but were repelled by the cost of fresh water.

* See table on page 56.
† Statement of Mr. Warren McBryde, Consulting Engineer, San Francisco.

Industries are likely to be frightened by the mere fact that municipal water is selling at from 9 to 44 cents per thousand gallons and averaging over 24 cents, that private well supplies are not altogether reliable, and that river water is salty a portion of the year. On the other hand, if a careful investigation were made, it would probably show that all other factors were so favorable in the upper bay, and its water difficulties so far from being unsolvable, that the present unfavorable water situation could be materially discounted.

On its face, the proposal to solve the area's water difficulties by the construction of a salt water barrier would add another attractive location factor to the imposing list which the upper bay district affords, providing that such a project did not bring with it a marked increase in the tax burden of the area. If such an increase did result the barrier might repel rather than attract new plants.

CHAPTER IV

THE INDUSTRIAL SITUATION IN THE UPPER BAY AREA—PRESENT AND PROSPECTIVE

The only official description of the upper bay industrial situation is that published by the Federal Government in the "Market Data Handbook," issued by the United States Department of Commerce. The first, and also the latest number of the handbook (1929), gives the situation for 1927 as follows:

	Number of establishments		
Type of industry	*In Contra Costa County*	*In Solano County*	*Total*
Food and kindred products	29	19	48
Textiles and their products	1	0	1
Paving material	4	0	4
Iron, steel and their products	5	0	5
Machinery	3	1	4
Forest products	8	2	10
Leather and its products	0	1	1
Rubber products	1	0	1
Roofing material	1	0	1
Paper industries	2	0	2
Printing and publishing	15	11	26
Chemicals and allied products	19	2	21
Stone, clay, glass, etc., products	7	1	8
Metal products, except iron and steel	2	1	3
Tobacco products	0	0	0
Musical instruments	0	0	0
Transportation equipment	1	0	1
Railroad repair shops	4	2	6
Totals	102	40	142

Unfortunately the handbook does not separate out the industries of Richmond, which is in Contra Costa County, but in reality belongs to the east bay industrial area, rather than to the upper bay. From the questionnaire sent the industries, however, we are able to present the following tabulation of the *more important* upper bay industries, beginning at Pinole Point and extending on both sides of Carquinez Strait and Suisun Bay eastward to the mouths of the Sacramento and San Joaquin rivers:

Location and type of industry	*Number of industries*
Antioch—	
Fibreboard products	1
Canneries	3
Lumber products	1
Shipbuilding	1
Avon—	
Oil refining	1
Bay Point—	
Lumber products	1
Shipbuilding	1
Chemicals	1
Cement mill	1
Benicia—	
Canneries	1
Arsenal	1
Tannery	1
Chemicals	1
Tractor factory	1
Crockett—	
Grain cleaning, etc.	1
Sugar refining	1
Giant—	
Explosives	1

Location and type of industry	*Number of industries*
Hercules—	
Explosives	1
Martinez—	
Copper smelting	1
Lumber products	1
Oil refining	1
Pittsburg—	
Fish Products	2
Steel products	1
Chemicals	3
Asbestos products	1
Dairy products	1
Wood products	1
Rubber products	1
Brick works	1
Port Costa—	
Brick works	1
Grain cleaning, etc.	1
Oil products	2
Rodeo (Oleum)—	
Oil refining	1
Selby—	
Ore smelting	1
Vallejo—	
Navy yard	1
Flour milling	1
Dairy products	1

If one undertook to describe in a sentence the nature of the industrial activity in the upper bay, he would characterize it as the type which, for one reason or another, operates best outside of congested metropolitan areas and yet finds it highly desirable from the standpoint of either its markets or material sources to have at its command as good shipping facilities as location in a large port city would afford.

The Location History of the Area by Decades.

Not all of the dates when these industries were established are available. Such as were furnished in the questionnaire are the basis for the following location record by decades:

Before 1881		
Arsenal	1	(1850)
Navy yard	1	(1853)
Cannery (fruit)	1	(1870)
Cannery (fish)	1	(1875)
Grain cleaning	1	(1876)
Powder mill	1	(1880)
1881–1890		
Ore smelter	1	
Lumber products	1	
Grain cleaning	1	
Flour mill	1	
1891–1900		
Powder mill	1	
Oil refinery	1	
1901–1910		
Chemical plant	2	
Lumber products	3	
Sugar refinery	1	
Steel mill	1	
Cannery (fruit)	1	
Copper smelter	1	
Rubber mill	1	
Brick works	1	
Beverage factory	1	
1911–1920		
Oil refinery	2	
Chemical plant	1	
Dairy products	1	
Rock products	1	
Lumber products	1	
1921–1930		
Paper products	1	(1927)
Cannery (fruit)	2	(1921) (1928)
Cannery (fish)	1	(1927)
Chemical plant	2	(1923) (1930)
Shipyard	2	(1926) (1928)
Lumber products	1	(1927)
Dairy products	1	(1922)
Asbestos products	1	(1025)
Tin plate mill *	1	(1929)
Brick works	1	(1930)

* Built in connection with then existing steel mill.

It is evident that during each of the decades given, at least one important industry has chosen the upper bay as its location. Viewed from the standpoint of present size of plants and value of output, 1901–1910 seems to have been the "golden era" of industrial establishment in the upper bay.

The decade just coming to a close has been distinguished by three outstanding developments: (1) The Johns-Manville Company established an asbestos products plant (1925); (2) The Steel Corporation (1929) built a tin plate mill in connection with its steel mill; (3) The Shell Products Company is establishing a large chemical plant (1930).

The new tin mill is the first one to be built west of St. Louis. It was erected at a cost of $3,000,000 and its corps of new workers materially increases the steel corporation's labor force at Pittsburg. The fact that 18 per cent of the national output of tin plate was used on the coast prompted this development. All of the raw materials but the tin are produced in Utah. The latter is brought direct by steamer from the Straits Settlements. Making the tin plate near the source of consumption avoids the heavy rust and other damage (10 per cent) incurred in ocean shipments from the east.

The Effect of Salinity on Plant Location.

An effort was made in connection with this study to obtain accurate information as to what industries, if any, have been lost to the upper bay area because of the salinity problem, but results were not satisfactory.* Since no dependable list can be made, one can only report the "hunches" of numerous individuals. The result is that in the case of no industry can it be said without fear of contradiction that it was or was not frightened away from the upper bay because of the salinity problem.

As was pointed out earlier, the tangible location factors, themselves, are many and they are interwoven in complicated fashion. Add to that the intangible personal factor and it is but natural that one finds much difference of opinion as to what led to the location of a given plant in a given place. Even responsible people and the industries themselves frequently find it difficult to single out the ultimate determining element.

Present Growth of the Upper San Francisco Bay Area.

It would be highly desirable to compare the growth of the upper bay area with respect to employees, wages, capital investment, value of output and other items with (1) the United States, (2) with California, and (3) with other local industrial areas.

Unfortunately, there are no census figures for the upper bay area as such. These for the United States and for California are available for 1904, 1909, 1914, 1919, 1923, 1925 and 1927. The 1929 census has been taken but the data will not be compiled for many months; the material in the 1927 census of manufactures did not become available until 1929.

Data obtained by the questionnaire method are never wholly satisfactory. No matter how carefully the questions are framed, different

* Two large industries which chose another location after considering various sites in the San Francisco Bay region have written as follows: Industry A: "The chief factors taken into consideration were adequate supply of satisfactory labor with adequate housing facilities in vicinity of plant site, sufficient power at reasonable rates, and adequate water supply at no cost except cost of pumping. A large ——— factory needs large quantities of fresh, cool water, and being assured of an ample supply underneath its plant with low pumping cost was one of the main factors in selecting the ——— site." Industry B: "The water situation was one of a number of factors which influenced our decision to locate in ———, but it was not necessarily the deciding factor."

interpretations will be placed upon them and will render them incomparable, at least to some extent. In this case some industries did not care to reveal certain facts about their operations, while others did not have the requisite records at hand. Particularly with respect to the capital investment figures and those covering water costs, reservations will have to be made. The replies do, however, represent a sufficient percentage of the whole and probably sufficient comparability to warrant their use in showing trends since 1924.

The following figures indicate the relative change in recent years, in the three areas given:

Value of the product of industries

	In U. S.	*In California*
1919	$62,000,000,000	$1,981,000,000
1921	43,618,000,000	1,758,000,000
1923	60,529,000,000	2,214,000,000
1925	62,668,000,000	2,442,000,000
1927	62,718,000,000	2,593,000,000

In the Upper Bay Area (partial total)[1]

1924	$71,066,000	1927	$84,840,000
1925	80,463,000	1928	91,023,000
1926	84,172,000	1929	90,516,000

[1] Includes only those industries furnishing these data for all six years in State Engineer's questionnaire, being Nos. 1, 2, 8, 11, 15, 19, 21, 23, 25 and 28, as shown in the list of industries at end of this report.

During the past five years the average annual growth in value of products in the upper bay has been approximately 5.5 per cent. From 1923 (the first year given after an acute depression) until 1927 the average annual increase in the value of product for the United States as a whole was slightly less than 1 per cent, and for California 4.3 per cent. It is greatly to be regretted that data do not exist for tracing the trends back over an extended period for all three areas. It is needless to point out that comparisons for such short periods lose much of their value.

Number of employees in industries
Average for the year

	In U. S.	*In California*
1919	8,997,900	243,700
1921	6,944,300	198,300
1923	8,776,600	246,100
1925	8,381,500	249,500
1927	8,349,700	262,800

In the Upper Bay Area (partial total)[1]

1924	8,854	1927	10,048
1925	9,566	1928	10,954
1926	10,324	1929	12,195

[1] Includes only those industries furnishing these data for all six years in State Engineer's questionnaire, being Nos. 1, 2, 8, 10, 11, 14, 15, 19, 20, 21, 23, 28, 31, 32, 33, 35 and 37, as shown in the list of industries at end of this report.

During the years 1924–1929 the average annual increase in workers employed in upper bay industries has been 7.5 per cent. For the

United States as a whole there was a decrease of industrial workers from 1923 to 1927, and for California an increase of not quite 2 per cent.

Growth of payrolls

	In U. S.	*In California*
1919	$10,460,000,000	$305,000,000
1921	8,200,000,000	284,000,000
1923	11,007,000,000	353,000,000
1925	10,727,000,000	350,000,000
1927	10,848,000,000	378,000,000

In the Upper Bay Area (partial total)[1]

1924	$13,993,000	1927	$16,594,000
1925	15,369,000	1928	18,029,000
1926	17,010,000	1929	21,123,000

[1] Includes only those industries furnishing these data for all six years in State Engineer's questionnaire, being Nos. 1, 2, 8, 10, 11, 15, 19, 20, 21, 23, 28, 29, 31, 32, 33, 35 and 37, as shown in the list of industries at the end of this report.

From 1924 to 1929 the average annual increase in the upper bay payroll was slightly more than 10 per cent. For the United States as a whole from 1923 to 1927, there was a decrease during the first biennium and, from 1925 to 1927, an average increase over the preceding biennium of slightly more than 1 per cent, and for California an increase over the four years of 1.8 per cent.

Growth of the capital investment

Since the government does not include this item in its enumerations we shall not be able to make comparisons, but the partial * upper bay figures are:

1924	$26,262,000	1927	$28,930,000
1925	26,453,000	1928	31,928,000
1926	27,876,000	1929	34,851,000

As noted previously, this item is particularly susceptible to wrong interpretation. However, though the totals for the several years may not be dependable, they serve to confirm the impression of steady growth obtained from the other data, showing an average annual growth of over 6 per cent.

While no one knows what the growth might have been under other conditions, the figures we have been able to procure indicate that a healthy expansion has been going on in the upper bay area, at least since 1924. Separate computations of the average annual growth in value of products, number of employees, payroll and capital investment in the area north of San Pablo Bay, including Napa and Petaluma, show rates of growth for these items that are practically identical with those just given for the upper bay area, and furnish some additional confirmation of the steady expansion of industry in the entire area since 1924.

The Prospective Growth of the Upper Bay Area.

Representatives of the industries themselves, when asked to predict their water needs for 1940, placed their total requirement at 44 billion gallons annually, an increase of 54 per cent over present consumption. This, of course, makes no allowance for new industries. If the *plant*

* Includes only those industries furnishing these data for all six years in State Engineer's questionnaire, being Nos. 1, 2, 9, 10, 11, 14, 15, 21, 25, 28, 31 and 33, as shown in the list of industries at the end of this report.

investment increase of existing industries keeps pace with this estimated growth in water requirements, the 82 millions of dollars given for 1929 in the following table will have increased to 127 millions, and assessed valuation, which averages about a third of plant investment, will have increased by approximately 15 millions. But the rates of increase in investment, payrolls, employees and value of product have all been somewhat greater during the past five years than these amounts would indicate. Each decade has witnessed the establishment of important new plants.

If the average annual rate since 1924 continues until 1940, we should have the following picture of the industrial set-up of the upper bay area in 1940:

		Partial totals for 1929 [1]	*Corresponding partial total for 1940*	*Partial totals in estimated per cent of totals for all industries*
(a)	Capital investment	$82,346,000	$135,200,000	75
(b)	Number of employees	14,100	25,800	88
(c)	Payroll	$23,654,000	$ 50,200,000	92
(d)	Value of output	$172,111,000	$276,200,000	61

[1] Includes all industries in area that made returns in State Engineers' questionnaire; or, by reference to numbers in list of industries in table at the end of this report:

For (a) Nos. 1, 2, 3, 9, 10, 11, 14, 15, 17, 21, 25, 28, 29, 30, 31, 33, 34, 35, 37 and 38.
For (b) Nos. 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 14, 15, 17, 19, 20, 21, 23, 25, 28 and 30 to 38, inclusive.
For (c) Nos. 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 14, 15, 17, 19, 20, 21, 23, 25 and 28 to 38, inclusive.
For (d) Nos. 1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 15, 17, 19, 21, 23, 25, 28, 29, 30, 31, 34, 35, 36 and 38.

In making these calculations it was assumed that the actual *amount* (not *per cent*) of increase shown the last five years will continue during the eleven years from 1929 to 1940. No one knows what the future has in store with respect to any economic situation. It is a reasonable assumption, however, that, given an adequate low-cost supply of fresh water for boiler, process, and similar needs, the industrial growth of the upper bay area will at least maintain its present rate. In the first place, except for a limited list of industries, confined, for one reason or another, to some particular eastern or foreign locality, the establishments represented by the three hundred thirty odd commodities in the Census of Manufactures *will tend to serve the Pacific coast market from Pacific coast plants.*

The following reasons are offered in justification of this assumption:

I. A recent report on industrial development in the United States and Canada compiled from information received from manufacturers, shows that accessibility of markets is the outstanding location factor in the minds of some sixteen thousand firms.

II. Pipe lines for natural gas and oil and long distance electric transmission lines have all but wiped out differences in power cost in the several market areas.

III. The rapid progress of the science of industrial chemistry has (a) provided new raw materials, (b) made possible the utilization of lower grade and waste products.

IV. Similar progress in the engineering field has eliminated much of the highly skilled labor force which tied industries to certain areas.

V. Improved transportation and new deep waterways have given cheaper access to raw materials.

VI. The west has attracted so heavy a migration of workers from the east, Mexico and the Philippines, that a surplus of labor is available in most fields.

VII. National advertising with its playing up of standard brands has built up a sufficient western demand for the products in question to warrant the establishment of plants on the coast from which a more satisfactory distribution service can be maintained.

VIII. So far as industrial processes are concerned, heat, humidity, and other physical factors have lost their dominating influence over plant location since artificial controls have been devised, hence any unfavorable climatic elements which might be present in a western location would no longer act as a hindrance to the establishment of certain types of industry in this area.

IX. The records show that industries actually are developing faster on the coast than in the United States as a whole. In the period of economic recovery, beginning with 1923 and ending with 1927 (last census available), the average annual rate of growth of industrial output was 0.8 per cent for the United States and 4.3 per cent for California.

X. The following tables procured from the Research Department of the Oakland Chamber of Commerce show how the railroad rate structure with but few exceptions favors distribution of even high-class shipments from the San Francisco Bay region over the sections indicated.

FREIGHT RATE PER 100 POUNDS, FIRST CLASS

Destination	From San Francisco Bay territory	From Ohio territory	From Illinois-Wisconsin territory	From Iowa, Missouri, Arkansas, Louisiana territory	From Indiana-Michigan territory	From Northeast and middle Atlantic territory
Boise	$3.31	$4.80	$4.35	$4.20	$4.57	$5.25
Butte	2.95	4.95½	3.98	3.71	4.77	5.40
Casper	4.20	4.95½	3.98	3.71	4.77	5.40
Denver	3.66	3.70	2.73½	2.46	3.52½	4.15½
Eureka	.84½	6.24½	5.94½	5.79	6.09½	6.39½
Los Angeles	.84½	5.40	5.10	4.95	5.25	5.55
Phoenix	2.67½	4.80	4.35	4.20	4.57½	5.13
Portland	.72	5.40	5.10	4.95	5.25	5.25
Reno	1.13½	4.80	4.35	4.20	4.57½	5.25
Salt Lake City	2.16½	5.31	3.98½	3.71	3.98½	5.37
Santa Fe	3.66	4.31½	3.34½	3.04	4.13½	4.76½
Seattle	1.39½	5.40	5.10	4.95	5.25	5.55

XI. With an anticipated decline in relative importance of the European trade of the United States, and an increase in the growth of trade with the Orient and Australasia, the *time* element involved in supplying the nations on the Pacific from Atlantic coast industries is a factor which works in favor of the establishment of additional branch plants on the Pacific coast. It should be added, of course, that as the trade with Asia and Australia increases, branch plants will begin to be built in that trade area also. In the second place, western state consumption of products of the type produced by upper bay industries is probably well in excess of the average for the country as a whole, and the population of this consuming area is growing faster than the United States as a whole. In addition, the exports of these same products

from Pacific coast ports have been increasing even faster than domestic consumption.

Advertising firms and sales managers, in fixing sales quotas for various territories, calculate the percentage of the total output which the users in a given territory are likely to buy. This is done by taking such indicia as population, bank deposits, telephone connections, incomes, etc., and arriving at a resultant percentage of probable consumption, or the sales quota. The latest obtainable quota for the eleven western states is 10.2 per cent. Assuming that substantially this same percentage of the products of heavy users of water is consumed in this western state area, we can ascertain its consumption of this type of products by taking 10.2 per cent of the national consumption (domestic production plus imports less exports).

The following is the list of heavy water-using industries which are at all likely to supply western and export demand from plants located in the upper bay area:

	Consumed in west	*Exported from Pacific coast*
Rubber products	$110,000,000	$4,650,000
Glass	28,200,000	300,000
Iron and steel products	322,000,000	2,020,000
Petroleum products	214,000,000	111,600,000
Asbestos products	4,500,000	260,000
Pipe	9,500,000	400,000
Paint and varnish	52,000,000	800,000
Chemicals	54,800,000	830,000
Soap	28,700,000	230,000
Sugar	70,300,000	100,000
Explosives	7,200,000	1,200,000
Leather	53,700,000	3,640,000
Roofing	12,300,000	630,000
Slaughtering, etc.	305,000,000	650,000
Totals	$1,272,200,000	$127,310,000

Estimated total consumption for 1927, $1,399,510,000.

At the rate of growth in the population of the eleven western states, predicted by population experts, there should be a 35 per cent increase in consumption in 1940. This would raise the item $1,272,200,000 to $1,717,470,000. If the same present trend continues with respect to export trade, the $127,310,000 in exports of products of the listed heavy water users will have increased to $200,000,000 by 1940, making a total demand of $1,917,000,000 in this market, for the products of the industries most likely to locate in the upper bay area. With its very attractive list of location factors, the upper bay area can reasonably be expected to maintain its present rate of increase and receive its share of the additional increment carried by the westward movement of industrial plants. No one is so rash as to think that *all* of this market's demand for the products of heavy water using industries will be supplied within this area, but the estimated consumption figures show what an attractive goal lies before the upper bay industries. Just how much of this estimated maximum volume of business the upper bay area could succeed in securing, no one can foretell. Such intangibles as community spirit and morale, relative skill at industrial salesmanship, and industrial area programs, often more than offset the tangible attractions of an industrial site.

CHAPTER V

THE PROBLEM OF WATER COSTS IN THE UPPER BAY AREA

As we saw in Chapter III, upper bay industries obtain their supplies of water from three principal sources: (1) public supply systems, (2) private wells, (3) the rivers—meaning by the latter also supplies of water pumped from any of the bodies of water which comprise upper San Francisco Bay. In all three cases, water cost figures should include all expense attached to whatever transmission and distribution lines, pumps, storage facilities and treatment are needed. Not only water bills and actual operating costs are involved, but also interest, maintenance and depreciation. In drawing up the questionnaire sent to the industries, great pains were taken to include all of these factors, but exact comparability of data was probably not secured.

Cost as Related to Source.

The cheapest sources of water supply are lakes, streams and wells, in close proximity to the place of use and obtainable either by gravity diversion or by low pumping lifts. Where water supply must be pumped, the cost of water for any given capacity varies directly with the magnitude of pumping lift. As a rough approximation, for every $100 spent to pump a given quantity of water through a head of 10 feet, $2,500 must be spent if the pumping head is 210 feet.

Water from Underground Sources.—For supplies obtained from underground sources there are often other disadvantages which tend to increase the cost above similar supplies obtained from lakes and streams. There is usually a definite limit to the amount of available water in any underground reservoir and an overdraft by excessive pumping frequently results in a lowering of the water table. The variation and increase in pumping head that often occur, result in increased pumping cost. Moreover deep well pumping equipment is generally more expensive and of lower efficiency than surface pumping equipment and these combine to further increase the cost of pumping from underground sources.

Those large upper bay industries which now pump from an underground water supply with low lifts at their plants report costs of two to three cents per thousand gallons, while with less favorable conditions the corresponding cost rises to nearly 25 cents per thousand gallons. Such water is harder than river water and, therefore, usually requires treatment for boiler use. The smaller user of well water naturally has a greater expense per thousand gallons consumed, and his costs are found to range from 11 to 83 cents per thousand gallons. If an abundant underground supply, with a low pumping head, can be found at one's plant, this furnishes an economical solution for his water problem. But as has been pointed out before in this study, the status of the underground water in the San Francisco Bay region does not warrant our looking to that source as the principal dependence of domestic and industrial users.

Water from Public Supply Systems.—Water furnished by existing public supply systems in the upper bay is relatively costly, even at the lower rates quoted to large users. First, no one water company has a

sufficient volume of business to enable it to operate at the optimum volume and minimum cost. Second, public water supplies are designed for human consumption and are commonly subjected to such treatment as will make the water sterile and palatable. For many industrial needs raw rater would serve just about as well, hence when industries buy their water from a public system they are paying for unnecessary frills. Third, for a large supply of water, the public company or municipality must resort to a stream. Wells are used by some smaller public systems in the upper bay, but the major company in the area has ceased to rely upon this source. If river water is obtained from above the salinity encroachment area, the cost of a long pipe line is incurred in addition to the usual purification expense. If the water is pumped close at hand, there must be sufficient additional storage, main, and pump capacity to procure and store, during the fresh water period in winter and spring, a sufficient supply to carry consumers through the dry and saline period of the summer and fall.

It is not surprising then to find the industries reporting total water costs all the way from 11 to 93 cents per thousand gallons for the portion of their supply which they receive from public systems. Except for about a half dozen companies in the area the amounts consumed are small and the relatively high unit costs include the expense of special treatment or equipment, or both.

So far as boiler, drinking, sanitary and other similar needs are concerned, the total volume required is so small in most industries that what seems like a heavy rate per thousand gallons places no substantial burden upon them.

Water for Process Purposes.

The amount and quality of water required for processing varies greatly with the industry. In the case of sugar refining, the large amounts of process water used must be unusually free from salt. The California and Hawaiian Sugar Refining Corporation, Limited, state that they have paid as high as 4 per cent of their cost of manufacture for water, but they estimate that their newly acquired source of supply will reduce their present cost of water by some 30 per cent.

Others, like the rubber and paper industries, require large amounts of process water. The rubber company evaporates river water for process uses and claims a loss in their devulcanizing plant during the high salinity period of 1929, amounting to $2,250 per month.

The sugar company is not disposed to risk the water in a barrier lake for process purposes, being content with the new source of supply of which we have just spoken. Industries in the Pittsburg-Antioch area which use a large quantity of water for processing, pump it from the river, except when the salinity is too great. They must then resort to public or private supplies. The river supply for process purposes is procured by the largest user at 1.5 cents per thousand gallons. A group of moderate-sized river water consumers report somewhat higher costs for process water generally, ranging from slightly more than one cent to over 12 cents per thousand gallons, while one of the smaller users reports his cost in excess of 30 cents. The largest user, to which reference was made above, places its annual loss, because of inability

to process with river water all twelve months, at some $1,600—the amount paid for public supply water in excess of the cost of pumping it from the river. This amounts to 0.04 of 1 per cent of the value of this company's annual output and 0.3 of 1 per cent of its annual payroll.

The use for purposes other than cooling and condensing amounts to 425 million gallons per month for all of the upper bay industries included in this study, while the use for cooling and condensing amounts to 1880 million gallons per month. Of the 425 million gallons used for all other purposes, the one industry which was referred to as having suffered a loss of $1,600 a year uses nearly 115 million gallons, or more than one-fourth of the entire amount.

Water for Cooling and Condensing Purposes.

Cooling and condensing water is required in very large quantities in the steel, oil, rubber and sugar industries, some of the wood products and chemical plants and at the navy yard. Unless an industry is particularly well situated with respect to the other factors, industrial engineers consider that it can not afford to pay more than six cents per 1000 gallons for cooling and condensing water. The following table shows what water for this purpose is costing typical large users in the upper bay:

Industry	*Annual consumption, in millions of gallons*	*Cost per thousand gallons, in cents*
A	1,050	1.8
B	1,420	2.6[1]
C	840	1.1
D	1,020	7.7[2]
E	490	1.2
F	7,290	0.8

[1] Three per cent of this water from private wells, but has no material effect on unit cost.

[2] In this case 2 per cent of the water is obtained from public supply and has the effect of increasing the average cost about 7 per cent.

Effect of Salinity.—So far as quantity of water and the cost of pumping are concerned it can be seen that industries on the upper bay have a very attractive situation. As we noted in another connection the difficulty lies in the damage caused to cooling equipment by salt water action during the salinity period. There are two ways of eliminating the more rapid deterioration of cooling equipment due to salt water action: (1) By substituting the somewhat more expensive salt-resisting equipment for the present cooling apparatus as fast as the latter needs to be replaced (any extra expense for the new type of equipment ought to be offset to some extent at least by the lower depreciation charge); (2) by providing a supply of fresh water to the industries, in such volume, and at such a price, as would warrant its use for cooling and condensing, either by building a barrier or by importation by means of a conduit from the most practical source.

To evaluate the additional expense of salt-resisting cooling and condensing equipment over similar nonsalt-resisting equipment, four of the larger typical users were interviewed and their estimates of maintenance, depreciation and capital cost for both types of equipment obtained. A wide variation occurred in the answers obtained, due

largely to the types of industries selected. All of the industries in the upper bay area were then classified into four groups, one for each of the industries interviewed, in accordance with the similarity in their use of cooling and condenser water. To each of the industries in the same group the rate of increase in capital and annual cost per unit of consumption for the industry interviewed was assumed to apply and, in combination with any industry's total use of cooling and condenser water, gave the total increase in capital and annual cost for the industry. Based on this method of analysis and on the data obtained from these larger typical industries, it is estimated for all industries in the area that the capital cost for cooling equipment designed for salt water conditions would be about $200,000 more than that for equipment designed for fresh water conditions; and that the annual cost of cooling water under salt water conditions and with salt-resisting equipment would be about $150,000 more than under fresh water conditions and with fresh water equipment.

The above estimated amounts of increased capital and annual cost apply to all of the industries in the entire area above Richmond. For the industries above the Dillon Point site only, the corresponding estimated amounts would be $175,000 as the increased capital cost, and $138,000 as the increased annual cost.

It is believed that the above figures present a reasonably accurate picture of the total value of fresh water for cooling purposes to the entire area. They represent an increase in total capital cost of less than one-fifth of one per cent and an increase per thousand gallons of cooling and condenser water of less than two-thirds of a cent. This estimate of the additional expense of salt-resisting cooling equipment is for a complete change from nonsalt-resisting to salt-resisting equipment for the present salinity conditions; neither of which conditions are generally applicable to the upper bay area. Practically all of the industries have some of each type of equipment, being more nearly on the salt-resisting basis as the industry is further downstream.

To estimate the decrease in cost of cooling and condensing water with fresh water available above a barrier, the following alternate method of analysis is presented. The present costs of cooling water were reduced by the decreased depreciation figures estimated by the industries themselves in the State Engineer's questionnaire for fresh water conditions as against present conditions. This resulted in the estimated amount of $70,000 as the indicated saving, which includes all industries above Richmond in the entire area. For the industries above Dillon Point site only, this corresponding estimated amount of indicated saving would be $43,000. However, the additional reduction in annual charges due to less interest on a smaller capital investment and to lower maintenance cost that could be obtained with fresh water are not included. The previous study for a complete change of equipment indicated that depreciation constituted the major portion of the difference and, therefore, it is thought that the true value of fresh water for cooling and condensing purposes lies somewhere between the two figures of $70,000 and $150,000 for the industries in the entire area above Richmond and $43,000 to $138,000 for the industries above Dillon Point site only.

That the extra cost of using salt water for cooling and condensing purposes over fresh is quite small is substantiated by the following

letter received from a concern which uses pure sea water exclusively for these purposes:

> It does not seem to us that there is any additional cost of operation of steam condensing equipment utilizing salt water, as compared with fresh water. The principal source of expense with condensers, is condenser tubes, and there is a very wide variation in the life of tubes of different manufacture.
>
> Admiralty Mixture brass tubes are rather generally used for plants using salt water, and for plants using fresh water about one-half use this same tube, and the other half use Muntz Metal, which latter are about 10 per cent cheaper than Admiralty.
>
> Our experience indicates that the use of salt water in the average life of condenser tubes is about four years. However, we have had variations from six months to twenty-five years. The data which we have, indicates that fresh water plants obtain about the same life.
>
> Temperature of the condensing water is a very important condition, because the higher the temperature, the larger the surface required in order to obtain the same vacuum, or a larger volume of circulating water must be handled.
>
> With higher temperature fresh water, quite often sludge is formed in the tubes, which offers resistance to the flow of water; reduces the vacuum, and is quite troublesome to remove, sometimes requiring chlorination of the water as a preventive measure. At times fresh water carries incrusting solids which form scale in the condenser tubes, reducing turbine efficiency, and is troublesome to remove.
>
> We are of the opinion that there would be but slight, if any, advantage of locating a steam power plant so as to utilize fresh water for condenser purposes.

A competitor of the above company states in reply to a similar inquiry that:

> The extra cost of using salt water over fresh water of the same temperature for condensing purposes is about 25 cents per million gallons pumped.

Still further evidence that the cost of cooling with salt water may not be much greater than with fresh is presented by a firm which manufactures cooling and condensing equipment and which replied that:

> The increased cost of supplying Admiralty Metal tubes in place of Muntz Metal tubes would amount to about 1½ per cent of the total cost of a condenser, the exact amount depending upon the size of the equipment and its construction.

They were unwilling to estimate the relative deterioration rate with salty and fresh water because it has been their experience that similarly equipped plants in comparable locations have had widely differing rates of deterioration. They attribute much of the mischief done to upper bay equipment to sewage and various contaminations introduced by waste products from industrial plants.

So far as the manufacturing costs of present industries are concerned, therefore, it is a question of letting them continue to bear whatever added expense salt water corrosion occasions or of substituting one of the two alternatives just set forth.

Relative Importance of Water Costs.

Since we have no data covering the relative importance of the various items which go to make up the respective manufacturing costs of upper bay products, we can not say with assurance just how consequential the cost of water really is. The nearest approach we can make is to compare total expenditures for water with such other items as are available, viz, capital investment, payroll and value of output.

The following table has been compiled for 1929, for thirteen outstanding industries which submitted usable data:

RELATIVE IMPORTANCE OF WATER COSTS

Industry	Capital Investment[1]	Value of product[1]	Pay roll[1]	Cost of water (total)			
				Cooling water[1]	Other water[1]	All water[1]	As per cent of value of products
A	$3,068	$2,290	$368	$25.3	$33.0	$58.3	2.5
B	11,300	60,000	1,470	15.6	161.9	177.5	0.3
C	8,866	9,245	4,062	19.2	26.9	46.1	0.5
D	5,731	37,194	2,667	78.1	113.8	191.9	0.5
E	4,070	[2]12,000	1,284	42.0	40.4	82.4	0.7
F	----------	[2]4,250	570	----------	21.6	21.6	0.5
G	----------	3,961	1,323	55.9	63.2	119.1	0.35
H	1,342	1,883	447	9.5	3.8	13.3	0.7
I	2,000	2,870	543	5.9	9.0	14.9	0.5
J	----------	2,765	343	36.9	3.6	40.5	1.5
K	----------	[2]2,500	480	5.1	5.3	10.4	0.4
L	454	2,000	320	----------	3.5	3.5	0.2
M	854	2,696	186	----------	11.0	11.0	0.4
Totals	----------	$173,654	----------	----------	----------	$790.5	(mean) 0.45

[1] Values in thousands of dollars.

[2] Items so marked not furnished with the other data sent by the industries to the State Engineer. They are taken from the industrial survey made by the Byron Times, and published in its twelfth annual development edition, page 5.

Present Cost and Consumption of Water for Cooling and Condensing.

The following table for cooling and condensing water shows the present total consumption of water and the maximum, minimum and average cost thereof from public and private supplies, from river, and from all sources combined for the industries in the following areas:

A. Pittsburg-Antioch area above Chipps Island site.

B. Crockett-Pittsburg area—between Dillon Point and Chipps Island sites.

C. Richmond-Crockett area—between Point San Pablo and Dillon Point sites.

PRESENT COST AND CONSUMPTION OF COOLING AND CONDENSING WATER IN UPPER SAN FRANCISCO BAY AREA

Based upon data furnished by the industries

	Area A	Area B	Area C	Total A and B	Total Area
I. From public water supplies—					
a. Total consumption in million gallons per year		18.0	13.2	18.0	31.2
b. Maximum cost in cents per 1000 gallons		33.0	28.0	33.0	33.0
c. Minimum cost in cents per 1000 gallons		33.0	28.0	33.0	28.0
d. Average cost in cents per 1000 gallons		33.0	28.0	33.0	32.0
II. From private sources—					
a. Total consumption in million gallons per year	64.1			64.1	64.1
b. Maximum cost in cents per 1000 gallons	8.8			8.8	8.8
c. Minimum cost in cents per 1000 gallons	2.2			2.2	2.2
d. Average cost in cents per 1000 gallons	4.4			4.4	4.4
III. From river—					
a. Total consumption in million gallons per year	3,769.9	10,097.1	9,609.1	13,867.0	23,476.1
b. Maximum cost in cents per 1000 gallons	39.0	13.4	8.4	39.0	39.0
c. Minimum cost in cents per 1000 gallons	1.1	0.8	0.4	0.8	0.4
d. Average cost in cents per 1000 gallons	2.0	2.0	2.2	2.0	2.1
IV. From combined sources—					
a. Total consumption in million gallons per year	3,834.0	10,115.1	9,622.3	13,949.1	23,571.4
b. Maximum cost in cents per 1000 gallons	39.0	13.4	8.4	39.0	39.0
c. Minimum cost in cents per 1000 gallons	1.1	0.8	0.4	0.8	0.4
d. Average cost in cents per 1000 gallons	2.0	2.1	2.2	2.0	2.1

This table shows a regular small increase in the average cost of water from all sources as the distance downstream and the salinity increase, being 2.0, 2.1 and 2.2 cents per thousand gallons for areas A, B and C, respectively. The relatively low cost shown above for cooling water, the total use of which is over 80 per cent of the entire industrial water consumption, indicates a favorable situation for the industries as regards cooling water. The indicated saving for the entire area above Richmond, as previously estimated, which might be obtained in cost of cooling water supplied by a fresh water barrier lake, namely between $70,000 and $150,000 annually, does not appear to be of great importance.

Present Cost and Consumption of Water for Boiler and Process Purposes.

A similar table of consumption and cost of water for boiler, process and other uses is presented below with identical headings as regards sources and areas.

PRESENT COST AND CONSUMPTION OF BOILER AND PROCESS WATER IN UPPER SAN FRANCISCO BAY AREA

Based upon data furnished by the industries

	Area A	Area B	Area C	Total A and B	Total Area
I. From public water supplies—					
a. Total consumption in million gallons per year	43.3	358.7	777.6	402.0	1,179.6
b. Maximum cost in cents per 1000 gallons	50.0	93.0	60.0	93.0	93.0
c. Minimum cost in cents per 1000 gallons	11.0	29.0	14.0	11.0	11.0
d. Average cost in cents per 1000 gallons	21.0	35.0	38.0	34 0	36.4
II. From private sources—					
a. Total consumption in million gallons per year	891.1	260.6	26.7	1,151.7	1,178.4
b. Maximum cost in cents per 1000 gallons	37.0	24.5	83.0	37.0	83.0
c. Mlnimum cost in cents per 1000 gallons	2.2	1.8	2.8	1.8	1.8
d. Average cost in cents per 1000 gallons	3.5	23.8	10.9	8.1	8.1
III. From river—					
a. Total consumption in million gallons per year	2,265.7	154.4	324.3	2,420.1	2,744.4
b. Maximum cost in cents per 1000 gallons	4.8	7.2	12.7	7.2	12.7
c. Minimum cost in cents per 1000 gallons	1.1	0.8	6.7	0.8	0.8
d. Average cost in cents per 1000 gallons	1.4	6.8	12.4	1.8	3.0
IV. From combined sources—					
a. Total consumption. in million gallons per year	3,200.1	773.7	1,128.6	3,973.8	5,102.4
b. Maximum cost in cents per 1000 gallons	38.2	93.0	59.7	93.0	93.0
c. Minimum cost in cents per 1000 gallons	1.2	2.3	6.6	1.2	1.2
d. Average cost in cents per 1000 gallons	2.3	25.8	29.7	6.9	11.9

Estimated Cost for Present Consumption of Water from a Barrier Lake.

In the course of this study estimates, based upon the data submitted by the industries, have been made as to how much the making of the upper bay area into a fresh water lake would affect industrial water costs. Too much dependence should not be placed in the completeness and comparability of the results because thoroughly satisfactory figures would have involved a personal investigation at each plant conducted by a staff of experts. The estimated costs for present consumption are shown in the following table:

ESTIMATED COST FOR PRESENT CONSUMPTION OF WATER FROM A BARRIER LAKE

Based upon data furnished by the industries. Costs of water do not include any portion of a barrier cost or any extra expense that might be necessary for treatment or disposal works to obtain fresh water in or from a barrier lake

	Area A	Area B	Area C	Total A and B	Total Area
I. Cooling and condensing water—					
a. Total consumption in million gallons per year	3,834.0	10,115.1	9,622.3	13,949.1	23,571.4
b. Maximum cost in cents per 1000 gallons	35.7	12.9	8.4	35.7	35.7
c. Minimum cost in cents per 1000 gallons	1.0	0.7	0.4	0.7	0.4
d. Average cost in cents per 1000 gallons	1.8	1.7	2.0	1.7	1.8
II. Boiler and process water—					
a. Total consumption in million gallons per year	3,200.1	773.7	1,128.6	3,973.8	5,102.4
b. Maximum cost in cents per 1000 gallons	40.6	13.8	10.1	40.6	40.6
c. Minimum cost in cents per 1000 gallons	1 0	0.8	0.4	0.8	0.4
d. Average cost in cents per 1000 gallons	1 7	3.9	2 9	2.1	2.3

The indicated saving which might be realized for boiler and process water supplied from a fresh water barrier lake in place of present sources is considerably greater and more important than in the case of cooling water. For all industries submitting usable data the total estimated annual saving in the cost of boiler, process and other water, except cooling and condensing, would be about $500,000. This indicated saving, as estimated from the data furnished by the industries, includes the water supply at present used by the California and Hawaiian Sugar Corporation, which is about to complete a new water supply system to take care of its entire fresh water requirements for the present and for some years in the future. The figure also includes the indicated savings for all industries in the area above Richmond. For the industries above the Dillon Point site only the corresponding estimate of indicated saving would be about $190,000.

Since salty water is not suited to most of these boiler, process and other uses, the river supply has had to be supplemented by connections with wells and public systems. The marked difference in the figure for Area A and those for B and C is accounted for by: (1) the fact that the public supply is far cheaper at Antioch than elsewhere, (2) the fact that the wells in Area A are the best in the whole region, and (3) the fact that the salinity difficulty is the least in the upper area.

In all of the above estimates of indicated savings in cost of industrial water supplied from a fresh water barrier lake in place of present sources, it should be noted that no allowance has been made for additional costs which might become necessary either for water treatment or sewage and industrial waste disposal or for expensive water supply intakes. It is assumed that suitable fresh water could be obtained simply by pumping directly from a barrier lake close to the plant location on the bay shore. If expensive treatment and disposal works or water intake works were required, the cost of such works would tend to decrease the indicated savings estimated above.

Comparative Water Rates in Other Localities.

Some cities or water districts make special rates to heavy water-using industries on the theory that even though the rate is so low that it does not cover the cost of the service, the community will be the gainer because of the industrial growth fostered thereby. If the rate is based upon the economy of quantity consumption, such reductions are sound, but when they are so great as to constitute a "sop," the ultimate effects are bad. An industry is in business to make money and should pay its own way. The following table shows the rates charged large industrial users in leading American cities and the minimum quantity to which the minimum rate applies:

COMPARATIVE WATER RATES

City	Per 100 cubic feet	Per 1000 gallons	Minimum quantity to which rate applies
1. Atlanta	$0 09	$0 12	Excess of 20,000 cubic feet per month.
2. Baltimore	08	10⅔	Excess of 1,000,000 feet per year.
3. Chicago	06	068	
4. Cincinnati	12	16	
5. Cleveland	06	08	
6. Detroit	04	05⅓	Over 100,000 cubic feet per year.
7. Los Angeles	07	09⅓	Over 100,000 cubic feet per month.
8. Mobile		10	Rate to largest users.
9. New Orleans		07	Over 100,000 gallons per month.
10. Oakland	209	279	Over 50,000 cubic feet per month.
11. Philadelphia	04	05⅓	Over 1,150,000 cubic feet per year.
12. Pittsburgh, Pennsylvania		14	750,000 gallons or more per year.
13. Portland, Oregon	05	06⅔	Over 120,000 cubic feet per month.
14. San Diego	20	30	
15. San Francisco	216	288	For all over 33,000 cubic feet per month.
16. St Louis	05	06⅔	Over 1,000,000 cubic feet per month.
17. St. Paul	03	04	Over 500,000 cubic feet per month.
18. Seattle	04	05⅓	Over 30,000 cubic feet per month.

Three of the California cities listed are obviously making no material reduction to large consumers, while the fourth, with comparable water costs, has adopted a policy of fostering industrial development by means of attractive water rates to heavy users.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The Background of the Survey.

In the earlier part of this study the foundation was laid for this appraisal of the industrial problems of the upper bay area. An examination was made of the factors which govern industries in the selection of locations for plants. The conclusion was reached that plant location is becoming more a matter of careful independent investigation by the industry and less one merely of community boosting.

Chambers of commerce have an important legitimate role in connection with the location of industries, in the shape of collecting and placing at the disposal of industries reliable information relative to the several location factors, and in cooperating with one another in the formulation of sane and comprehensive plans for regional development.

Rating the importance of location factors, apart from a specific situation, is futile. Important exceptions exist for every generalization one can make. It is noteworthy, however, that the problem of markets seems to cause industrialists the greatest concern at the present time.

Progress in chemistry and engineering has done much to wipe out regional differences with respect to power, raw material, labor, water, and other important elements in plant operation. Hence many of the old bases of territorial specialization have been eliminated.

The census for 1930 shows that during the preceding decade the Pacific states area was the fastest growing part of the United States, California alone having gained 64.6 per cent in population since 1920. This western state market area with some 9 per cent of the country's population consumes over 10 per cent of the national industrial output.

The more rapid growth made by industries in California, compared with the United States as a whole, shows that the scientific progress to which we have just referred is enabling manufacturers to supply this large and rapidly expanding market from western plants. Coupled with the growth of domestic consumption has been the even more rapid expansion of the foreign trade of the Pacific coast ports.

As one studies the industrial problems of the San Francisco Bay region he is impressed with the economic unity and interdependence of its constituent parts. This fact calls for regional planning rather than community rivalry. Factors like labor supply, cost of living, rail and water transportation, power, raw materials and markets are satisfactory for the region as a whole and for each of its several subdivisions.

Industrial sites are available in every part of the bay region, those in the large cities being much more expensive and, therefore, probably better adapted to the multi-story type of plant. The larger industrial tracts vary from solid land to marshy or even water-covered ground. For the latter a considerable outlay will have to be made for reclamation work. Taken as a whole, the region offers almost unlimited room for factories on the extensive water front of the bay and its tributary rivers, and on the land farther back, but with access to water transportation.

Merits of the Upper Bay as an Industrial Area.

The upper San Francisco Bay area affords a most attractive combination of location factors for industries which require relatively large tracts of land, low cost transportation, proximity to large cities and, at the same time, the comparative isolation of a country site. Other parts of the San Francisco Bay region offer comparable advantages, but the south shore of Suisun Bay contains at present one of the cheapest areas of solid ground near to deep water in the whole bay region.

We have found that all of such major factors as labor supply and cost, power supply and cost, transportation (rail, water and highway), accessibility of markets and raw materials, have with very minor exceptions been reported as favorable by the industries of the area. The only consequential disadvantage set forth has been the encroachment of salt water during the season when the two rivers have too small a flow to repel the salinity invasion.

The growth of the industries which have built their plants in the area indicates that the advantages claimed for it are not mere "paper" ones. We have seen that such comparable data as were available revealed a rate of growth in value of product, number of employees and size of payrolls greater than that for the state as a whole and markedly more rapid than the trend for the whole United States.

All of this goes to prove that the upper bay is a valuable part of the industrial structure of the Pacific coast and that, if it is suffering from any remediable handicaps, serious consideration should be given to the problem of removing them.

The Water Problem of Upper Bay Industries.

Normally, water does not constitute a large part of the total cost of manufacture. Nevertheless it is just as essential to a water-using industry as are the most costly materials. Cooling and condensing call for large quantities of water. Here coldness is the quality most desired, although freedom from ingredients which cause abnormal deterioration of the cooling equipment makes possible a lower annual cost of cooling water because of the smaller initial outlay for cooling apparatus, decreased depreciation and maintenance, and a smaller consumption of water than is the case where special resisting materials are installed. However, the cost of cooling water is not large and the higher temperatures that would result in a barrier lake might offset the additional cost of salt-resisting equipment.

Upper bay industries obtain some of their cooling water from wells and from public supply systems, but for the most part it is pumped from Suisun Bay, Carquinez Strait or the lower end of the San Joaquin River. For convenience we have referred to all of this supply as river water, and quite properly so, for the water from the two rivers flows through the bay and strait on its way to the sea.

During the dry season, when a minimum of fresh water is being discharged into Suisun Bay from the rivers, the chlorine content of the water in the bay shows a marked increase. Naturally, the less the precipitation in the area drained by the rivers, the greater is the salinity in the bay. At such time those industries which have cooling apparatus designed to use fresh water suffer a loss from its abnormal deterioration.

Plants which have installed salt-resisting equipment have made a heavier initial investment and consume more water, but have reduced the depreciation rate very materially.

That coldness is after all the important quality in a cooling water is evidenced by the fact that great power plants are choosing sites on salt water where veritable rivers of cold salt water can be pumped through the cooling apparatus at a very low cost. One such concern, whose consumption of salt water for cooling is very heavy, reports that, including depreciation, its cooling water cost is but 1.3 cents per thousand gallons. In the upper bay, where the chlorine content is comparatively low, even when conditions are at their worst, the depreciation rate would be smaller.

So far as cooling and condensing use goes, and this constitutes more than 80 per cent of the total water consumption of upper bay industries, there is little justification for undergoing great expense in substituting a year around supply of fresh water. Based upon estimates from data supplied by the industries, it will be recalled that but $70,000 to $150,000 annually would be saved by the change to the fresh water of a barrier lake and that only in case the temperature of the water in the lake is not raised. The continued use of the present water with a more suitable type of equipment appears to be the logical solution of the cooling and condensing problem.

The presence of as great chlorine content as Suisun Bay contains during the period of low water in the rivers, makes the water undesirable at that time for use in boilers and for most of the processing carried on in the area. Salt can not be eliminated from water except at prohibitive expense. While Suisun Bay has never been fresh throughout an entire year, at least so far back as the Sugar Corporation's records go (1906), salinity encroachment is more serious than before water was diverted from the rivers so extensively for irrigation purposes. Then, too, we have had a cycle of low rainfall since 1917, and this has aggravated the situation.

It will be recalled that the annual indicated saving based upon the data obtained from the industries for water used for boiler, process and miscellaneous purposes would be about $500,000 with fresh water obtained from a barrier lake. It is doubtful if river water would suffice for all of these uses without treatment, and additional expense, which would tend to balance the indicated saving. It is obvious that the problem of a fresh water supply for the upper bay merits serious attention. The boiler and process costs of industries in the territory west of Pittsburg, which we designated as Areas B and C, judged by published water rates, are completely out of line with those of Los Angeles or Seattle, or with any of the industrial areas in the east. The boiler and process water costs in Area B averaged 25.8 cents from all sources, even when river water was available at a low pumping cost for a part of the year. In Area C the corresponding average of the small group which furnished data was even greater, viz. 30 cents per thousand gallons.

In the case of cooling and condensing water we found the figures furnished for the cost of river water are so low, even under existing conditions, that they do not seem to warrant any considerable outlay for an alternative source of supply. For other uses, the cost should be

materially lower than it is at present, particularly for industries situated west of Pittsburg.

Suggested Alternate Sources of Fresh Water.

Two methods have been suggested as a possible means of obtaining fresh water at a smaller cost than that from present sources and facilities:

I. *Importation from Sources Outside Local Area.*—If all of the upper bay region united to obtain its fresh water from a common source, a sufficient volume of consumption would be secured to warrant a large scale domestic and industrial water development. Water can be brought in from one of several adequate sources. Industrial demand for boiler, process and other water, except cooling and condensing, calls for 14 million gallons of fresh water per day, with an estimated consumption by existing industries in 1940 of 23 million gallons per day. If that part of the supply which is now bought from public systems could be furnished to large users at ten cents per thousand gallons with an additional allowance of, say, two cents per thousand for distribution and treatment, the average total cost of water for boiler and process use from combined river, public and private sources would be reduced to 6.3 cents per thousand gallons, inasmuch as industries would still be able to pump their supplies from the river during much of the year. At present, three billion of the five billion gallons used for boilers and processing is taken directly from the river, and the rest, in about equal amounts, from private wells and public supplies. If it be assumed that such a system as the one proposed would be self-supporting, there would be no tax burden to frighten industries away from the upper bay.

II. *Salt Water Barrier Lake.*—A fresh water lake can be created by constructing a barrier at some site yet to be determined. It is estimated that an annual charge of some four million dollars * would be incurred. The following are some of the alleged gains and losses to upper bay industries from the construction of a barrier.

SOME ALLEGED GAINS

1. A constant and ample supply of fresh water at the cost of pumping it.
2. Cheaper pumping cost and softer water than in the case of a deep well, where well water is to be had.
3. Removal of the present limitations which the water situation has placed upon industrial growth, including the introduction of new processes and products.
4. Prolonged life of cooling equipment.
5. Safer navigation and more dependable depth of water for the ships which serve the industries above the barrier.
6. Larger local market due to the stimulation of the area's growth.
7. Elimination of the destruction of piling by the teredo, a borer which can not live in fresh water.
8. Cleansing of ship bottoms by the destructive action of fresh water upon barnacles.

* Estimate of State Division of Water Resources based upon a capital cost for a barrier of $50,000,000 (including interest during construction), interest at 4½ per cent per annum, amortization for 40-year bonds, depreciation, and operation and maintenance.

SOME ALLEGED LOSSES

1. Heavy increase in the taxes of the beneficiary industries, unless much of the cost is assumed by the state, the federal government, or the two jointly.

2. Imposition of a tax burden upon industries which have no direct interest in a barrier.

3. Possible heavy expense for waste disposal in case the barrier causes Suisun Bay to be fouled from matter which would otherwise be carried out through the straits.

4. The obstruction to navigation due to the locks in the barrier, with resulting increases in freight rates.

5. Possible damage to plant sites from changes in the ground water level.

6. Shoaling of navigable channels when the scouring effect of the present open channel is lost.

7. Possible damage to industries below the barrier site if the salinity of their supply of bay water is considerably increased by the impounding of the fresh river water behind the barrier.

8. Possible destruction of the fishing and fish canning industries, if fish do not use the opened lock gates and the fish ladder for ascending to the rivers. The question is also raised whether the young fry which now descend to the ocean through water of gradually increasing salinity could survive a sudden change from the fresh water behind a barrier to the salty water below.

There are certain intangible losses now occurring that might be eliminated by a barrier lake and thus add benefit values. A typical loss of this character is the potential profit which might be realized from the manufacture of products which can not be profitably produced under present salinity conditions. There is insufficient information available to evaluate such benefits.

Most of the questions raised in these two lists involve a technical knowledge of civil engineering, navigation, ichthyology, or sanitation problems. Experts consulted did not agree as to what results could be expected. This much is clear, that some four million dollars * a year must be provided from some source or other if a barrier is to be built.

Estimated Tax Burden.—That the present industries, by themselves, could not bear the burden is clear. Even if all of the taxpayers of the two counties most directly concerned, viz, Contra Costa and Solano, assumed the obligation, a four-million-dollar * annual charge on their assessed valuation of 129 millions (1929) would increase taxes in the two counties by $3.10 per $100 of assessed valuation. The total tax rate in Pittsburg, for example, is now $3.63.

A tax from the two counties named of fifty cents per $100 of assessed valuation, such as has been imposed in the east bay for the new Mokelumne River supply, would raise less than one-sixth of the requisite amount for a barrier.

In order to estimate the *maximum* rate which industries in the upper bay could afford to be taxed for a barrier, the following table

* Estimate of State Division of Water Resources based upon a capital cost for barrier of $50,000,000 (including interest during construction), interest at 4½ per cent per annum, amortization for 40-year bonds, depreciation, and operation and maintenance.

has been compiled, covering those industries for which both assessment and water-cost figures were available:

MAXIMUM TAXABLE RATE FOR INDUSTRIES FOR A BARRIER

I Industry	II Assessed valuation	[1]III Estimated annual savings in water cost	IV Tax rate per $100 which would wipe out III
A	$344,000	$9,100	$2 65
B	173,000	4,900	2 83
C	1,663,000	21,600	1 30
D	83,000	100	12
E	44,000	0	0
F	306,000	900	30
G	5,292,000	159,300	3 01
H	3,754,000	114,600	3 05
I	387,000	4,800	1 24
J	5,483,000	64,800	1 18
K	458,000	22,700	4 96
L	254,000	3,400	1 34
Total or average for industries A to L	$18,241,000	$406,200	$2 23
[2]Total or average for entire area	$23,735,000	$480,000	$2 02
Total or average for industries above Dillon Point site only	$14,202,000	$223,000	$1 57

[1] The figures in Column III are the estimated indicated savings with a fresh water supply available in a barrier lake at the cost of pumping only, in place of the present sources and costs of water.
[2] Includes all large industrial water users except Mare Island Navy Yard.

The total indicated saving for the industries in the entire area corresponds to a tax rate of $2.02 per $100 of assessed valuation. However, for the industries above the Dillon Point site only the total indicated saving corresponds to a tax rate of $1.57 per $100 of assessed valuation. It should be noted that the increase in taxes which is estimated would occur for Contra Costa and Solano counties to take care of the estimated annual charge of a barrier costing $50,000,000 corresponds to a barrier located at or near Dillon Point. A barrier constructed at Point San Pablo, or nearby, would probably cost considerably more, or from $75,000,000 to $90,000,000. The tax rate which would wipe out the indicated estimated saving in water cost as computed for the industries above the Dillon Point site, viz, $1.57, is therefore directly comparable to the estimated increase in taxes, namely $3.10, to take care of the entire annual cost.

Basis of State or Federal Aid.—Appropriations received from the state or federal governments toward meeting the cost of a barrier would have to be put upon one or both of two bases: first, restitution for alleged damages due to changed conditions in the upper bay area which might be partially due to developments carried out on the two river systems under federal and state laws and auspices; second, recognition of a state-wide and nation-wide benefit in keeping with the contribution made to the project's cost.

Final Conclusions.

Accepting the statements made by the representatives of the industries in the area, regarding the losses they are sustaining from the salinity difficulty, the present volume of industrial activity and the

total loss alleged are far from being of a magnitude which would warrant so elaborate and costly a remedy as a salt water barrier.

The upper bay industrial area at present may be said to be "salinity conscious." So long as this state of mind prevails, it is bound to serve as an impediment to securing the share of industrial activity which the excellence of the area's attractions warrants. Definite steps should be taken to wipe out both the actual and the psychological handicaps which salt water encroachment has imposed.

A fresh water industrial lake in a region so endowed with other advantageous location factors would no doubt prove to be an attraction to heavy users of fresh water, but if there were attached to a site along the lake a tax rate which all but wiped out the benefits of the water supply, a barrier might prove to be a boomerang, so far as its drawing power was concerned.

Industries would not rush madly into the upper bay area even when a barrier was provided. Other areas with competing locations would probably match this attraction with counter attractions, such as comparable water-rate reductions. All of which means that the present generation would assume a heavy burden with only partial compensatory gains in the way of some saving in water costs and a stimulated industrial development.

If the entire gain credited to a barrier lake by the industries, viz, $570,000 to $650,000 per annum, were treated as the extent of damage done by irrigation, reclamation, power and other projects, this would amount respectfully to 14.3 and 16.3 per cent of the estimated total annual burden connected with a barrier.

Regions outside of the upper bay area would tend to be affected as follows by any development which stimulated its industrial growth:

I. *The East Bay.*— As one of the shopping centers for the upper bay district, the cities of the East Bay would benefit by the stimulation of the former's growth. Likewise individuals and firms in the East Bay who render professional and other personal service would benefit from an increased patronage from the upper bay territory. East Bay industries might benefit from being allowed to participate jointly with the upper bay in a project to furnish fresh water to industrial users at a cost considerably less than the 29.1 cents per 1000 gallons charged by the East Bay Municipal Utility District. If a barrier lake were created, a pipeline could be laid to the East Bay city, but as tax payers in the present Municipal Utility District and probable bearers of a part of the cost of a barrier if they enjoyed its benefits, might find that these two offsets made very substantial inroads into the anticipated saving in water costs.

II. *The Remainder of the Bay Region.*—San Francisco, as an important center for shopping, personal, professional and banking service, would also benefit by the stimulation of upper bay growth. Similarly, producers of poultry, eggs, fruit, vegetables and other products and services required by upper bay inhabitants, would profit by the larger market. In somewhat the same fashion producers of products and services needed by the upper bay industries would benefit. These gains are real, but not calculable in dollars and cents.

III. *The Rest of the State and the Nation.*—To the extent that a community profits more from industries located in its midst than it does from those farther removed, any other section of the state or of the United States would receive less direct benefit from the location of an industry in the upper bay than from the same establishment located in its own midst. Indirectly, it does reap a gain from new developments elsewhere which broaden the market for its products and provide it with new sources of supply for the things it consumes. It is not an easy task, however, to "sell" to areas with competing sites the idea of contributing to a project which is designed to increase the latter's competitive advantage, when they have no large volume of business with the upper bay.

The whole matter in a nutshell seems to be that, while the industries of the upper San Francisco Bay have water problems which need to be solved, they do not of themselves, for the present, at least, seem to justify so elaborate and costly a remedy as a salt water barrier. It is recommended, however, that serious attention be given to adequate measures for removing the causes of salinity consciousness in the upper bay area, and for providing an adequate supply of fresh water for industrial purposes in the most economical way which competent engineers can devise.

LIST OF INDUSTRIES IN UPPER BAY AREA

Limited to those with 20 or more employees

Division	Reference number	Name of industry	Location
Area A—			
Above Chipps Island Site.	1	Antioch Lumber and Mill Company	Antioch
	2	Hickmott Canning Company	Antioch
	3	West Shore Packing Company	Antioch
	4	California Packing Corporation	Antioch
	5	Fibreboard Products Company	Antioch
	6	Fulton Shipbuilding Company	Antioch
	7	National Chemical Company	Pittsburg
	8	Great Western Electro Chemical Company	Pittsburg
	9	Pioneer Rubber Mills	Pittsburg
	10	U. S. Steel Products Corporation	Pittsburg
	11	Redwood Manufacturers Company	Pittsburg
	12	Johns-Manville Company	Pittsburg
	13	F. E. Booth Company	Pittsburg
	14	Northern California Fisheries Association	Pittsburg
	15	Pioneer Dairy Company	Pittsburg
Area B—			
Above Dillon Point and below Chipps Island sites.	16	General Chemical Company	Bay Point
	17	Coos Bay Lumber Company	Bay Point
	18	Cowell Portland Cement Company	Bay Point
	19	Associated Oil Company	Avon
	20	Mountain Copper Company	Martinez
	21	Shell Oil Company	Martinez
	22	Western Plywood Company	Martinez
	23	Port Costa Brick Company	Port Costa
	24	Associated Pipe Line Company	Port Costa
	25	Port Costa Warehouse Company	Port Costa
	26	Benicia Arsenal	Benicia
	27	Yuba Manufacturing Company	Benicia
	28	California Rex Spray Company	Benicia
	29	G. W. Hume Company	Benicia
Area C—			
Above Point San Pablo and below Dillon Point sites (exclusive of Richmond and Napa-Petaluma area).	30	Grangers Business Association	Crockett
	31	C. & H. Sugar Refining Corporation, Ltd.	Crockett
	32	American Smelting and Refining Company	Selby
	33	Union Oil Company	Rodeo
	34	Hercules Powder Company	Hercules
	35	Giant Powder Company	Giant
	36	Sperry Flour Company	Vallejo
	37	Mare Island Navy Yard	Vallejo
	38	Maid of California Milk Company	Vallejo
Area D—			
Napa and Petaluma area.	39	Basalt Rock Company	Napa
	40	Cameron Shirt Company	Napa
	41	Keig Shoe Company	Napa
	42	Napa Fruit Company	Napa
	43	Napa Glove Company	Napa
	44	Napa Milling Company	Napa
	45	Napa County Prune Association	Napa
	46	Sawyer Tanning Company	Napa
	47	Petaluma Cooperative Creamery	Petaluma
	48	Belding Hemingway Company	Petaluma
	49	Camm and Hedges Company	Petaluma
	50	Golden Eagle Milling Company	Petaluma
	51	Coulson and Company	Petaluma
	52	Geo. P. McNear Company	Petaluma
	53	Swift and Company	Petaluma
	54	Western Ice and Refrigerator Company	Petaluma
	55	Petaluma Box Company	Petaluma
	56	Vonsen Company	Petaluma
	57	McNear Brick Company	McNears
	58	Daniel Contracting Company	McNears

SUMMARY OF CONTENTS OF STATE ENGINEER'S QUESTIONNAIRE

A. General and Miscellaneous Information.

Type of industry; Products; Date of location; Reasons; Advantages and disadvantages of site; Sources of raw materials; Markets; Power and fuel used; Period of continuous operation.

B. Description of Transportation Facilities.

Rail; Water; Highway.

C. Labor.

Source; Type; Adequacy of quality and quantity; Cost; Disputes.

D. Water Supply—From Public and Private Systems and the River.

Quality; Quantity; Pumps; Storage; Distribution; Treatment; Value of plant; Present consumption from each source for boiler and process, cooling and condensing, and other uses; Annual cost of water for each source; Estimate of financial loss due to salinity of water; Estimated demand in 1940 for each of the several purposes and sources; Proposed plans of the industry for water supply development; Importance of water to the industry; Desirable cost figure; Additional tax it could afford for satisfactory supply.

E. Domestic Sewage Disposal.

Area and population served; Quantity; Present and proposed methods of disposal; Description of outfall; Present and proposed methods of treatment.

F. Industrial Waste Disposal.

Quantity and type of waste; Description of outfall; Present and proposed plans for disposal and treatment.

G. Reclamation Works.

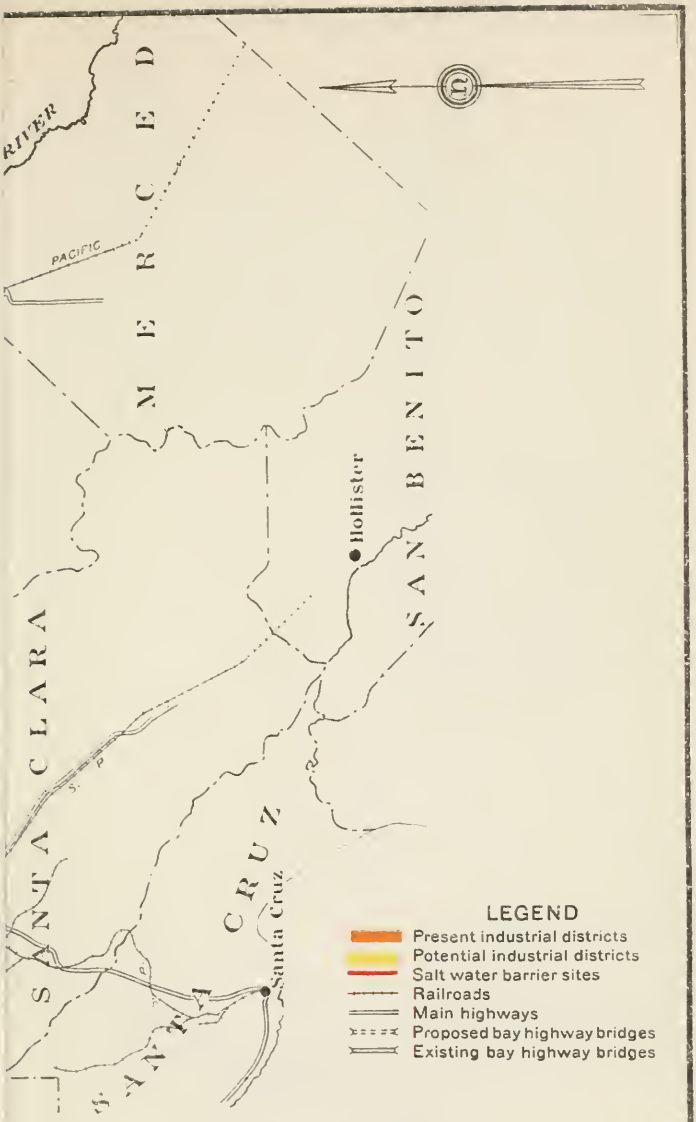
Present and proposed work; Areas involved; Drainage works, their cost and value.

H. Effect of Construction of a Salt Water Barrier.

Up river from the plant; Down river; Benefits and detriments.

I. Statistical Information (for each year from 1906 to 1929, inclusive).

Capital investment; Assessed valuation; Cost of raw material brought in from outside of county; Gross value of sales; Number of employees (average per year); Total pay roll; Annual consumption of boiler and process water, cooling and condenser water and water for other uses, from each of the three sources, viz, Public systems, private wells, the river; Annual water cost for each principal source and use; Total value of the water system and total annual maintenance cost for each of the three principal sources of supply; Estimated annual saving if suitable raw river water were available; Actual cost of treating raw river water for each of the types of use.



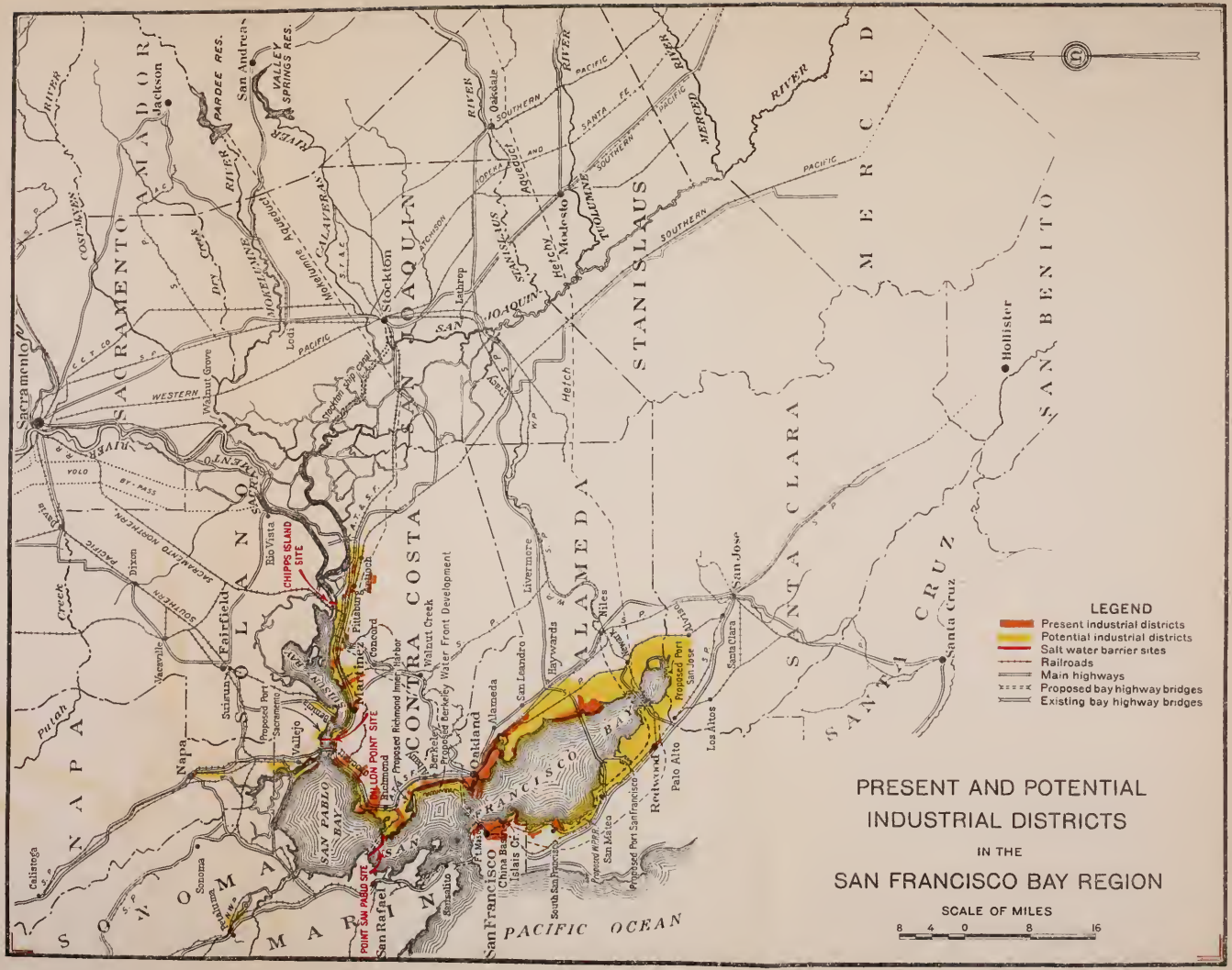
PRESENT AND POTENTIAL INDUSTRIAL DISTRICTS

IN THE

SAN FRANCISCO BAY REGION

SCALE OF MILES

8 4 0 8 16


LEGEND
Present industrial districts
Potential industrial districts
Salt water barrier sites
Railroads
Main highways
Proposed bay highway bridges
Existing bay highway bridges
PRESENT AND POTENTIAL
INDUSTRIAL DISTRICTS
IN THE
SAN FRANCISCO BAY REGION
SCALE OF MILES
8 4 0 8 16
SACRAMENTO
SAN JOAQUIN
STANISLAUS
MERCED
SAN BENITO
SANTA CLARA
SANTA CRUZ
NAPA
SOLANO
CONTRA COSTA
ALAMEDA
MARIN
SONOMA
SAN FRANCISCO BAY
SAN PABLO BAY
PACIFIC OCEAN
Sacramento
Stockton
Modesto
Hollister
San Jose
Santa Cruz
Oakland
San Francisco
Richmond
Vallejo
Napa
San Rafael
Martinez
Benicia
Fairfield
Suisun
Dixon
Davis
Woodland
Livermore
Hayward
San Leandro
Alameda
Berkeley
Concord
Pittsburg
Antioch
Tracy
Lodi
Los Altos
Palo Alto
Redwood
Petaluma
Sonoma
Calistega
Tamalpais
Sausalito
South San Francisco
San Mateo
Walnut Creek
Rio Vista
Walnut Grove
Isleton
Lathrop
Manteca
Ripon
Oakdale
Jackson
San Andreas
CHIPPS ISLAND SITE
MARTINEZ SITE
RICHMOND SITE
POINT SAN PABLO SITE
Proposed Port Sacramento
Proposed Richmond Inner Harbor
Proposed Berkeley Water Front Development
Proposed Port San Jose
Proposed Port San Francisco
China Basin
Islais Cr.
Mission Cr.
Coyote Cr.
Guadalupe R.
Alameda Cr.
Petaluma R.
Napa R.
Sacramento R.
San Joaquin R.
Mokelumne R.
Calaveras R.
Stanislaus R.
Tuolumne R.
Merced R.
Pajaro R.
Salinas R.
Pardee Res.
Valley Springs Res.
Delta-Mendota Canal
Contra Costa Canal
Stockton Deep Water Channel
Hetch Hetchy Aqueduct
Western Pacific R.R.
Southern Pacific R.R.
Santa Fe R.R.
Pacific R.R.
Sacramento Northern R.R.
Central Pacific R.R.
Bay Bridge
Golden Gate Bridge
Dumbarton Bridge
San Mateo Bridge
Carquinez Bridge
Benicia-Martinez Bridge
Antioch Bridge
Richmond-San Rafael Bridge
Golden Gate Bridge

LEGEND
1 to 58 Present major industries (Numbered as in List of Industries at end of this report)
Present industrial districts
Potential industrial districts
Salt water barrier sites
Railroads
Main highways
Main power lines
Water and Utility District boundaries
County boundaries
City boundaries
PRESENT INDUSTRIES
AND
PRESENT AND POTENTIAL INDUSTRIAL DISTRICTS
IN THE
UPPER SAN FRANCISCO BAY AREA
SCALE OF MILES
1 0 1 2 3 4
N
NAPA CO.
SOLANO CO.
SONOMA CO.
MARIN CO.
CONTRA COSTA CO.
Napa
Sonoma
Petaluma
Fairfield
Suisun
Cordelia
Vallejo
Benicia
DILLON POINT SITE
PROPOSED PORT SACRAMENTO
Selby
Oleum
Crockett
Port Costa
Avon
Bay Point
Clyde
Pittsburg
Antioch
Martinez
Concord
Walnut Creek
Hercules
Pt. Pinole
Pinole
Giant
San Anselmo
San Rafael
Ross
Larkspur
Mill Valley
Corte Madera
Richmond
El Cerrito
Albany
Berkeley
POINT SAN PABLO SITE
PROPOSED RICHMOND SAN RAFAEL BRIDGE
PROPOSED RICHMOND INNER HARBOR
CHIPPS IS. SITE
SAN PABLO BAY
SUISUN BAY
CARQUINEZ STRAIT
SAN PABLO RES.
CHENERY RES.
ANTIOCH CITY RES.
ALPINE RES.
MALLARD SLOUGH PUMPING PLANT
GRIZZLY ISLAND
SIMMONS ISLAND
HAMMOND ISLAND
WHEELER ISLAND
RYER IS.
ROE IS.
VAN SICKLE IS.
CHIPPS IS.
BROWNS IS.
WINTER IS.
MARE ISLAND
Petaluma River
Sonoma Creek
Napa River
Napa Slough
South Slough
Suisun Slough
Montezuma Slough
Sacramento River
San Joaquin River
Sacramento Co.

PUBLICATIONS

DIVISION OF WATER RESOURCES

PUBLICATIONS OF THE

DIVISION OF WATER RESOURCES

DEPARTMENT OF PUBLIC WORKS

STATE OF CALIFORNIA

When the Department of Public Works was created in July, 1921, the State Water Commission was succeeded by the Division of Water Rights, and the Department of Engineering was succeeded by the Division of Engineering and Irrigation in all duties except those pertaining to State Architect. Both the Division of Water Rights and the Division of Engineering and Irrigation functioned until August, 1929, when they were consolidated to form the Division of Water Resources.

STATE WATER COMMISSION

First Report, State Water Commission, March 24 to November 1, 1912.
Second Report, State Water Commission, November 1, 1912, to April 1, 1914.
*Biennial Report, State Water Commission, March 1, 1915, to December 1, 1916.
Biennial Report, State Water Commission, December 1, 1916, to September 1, 1918.
Biennial Report, State Water Commission, September 1, 1918, to September 1, 1920.

DIVISION OF WATER RIGHTS

*Bulletin No. 1—Hydrographic Investigation of San Joaquin River, 1920–1923.
*Bulletin No. 2—Kings River Investigation, Water Master's Reports, 1918–1923.
*Bulletin No. 3—Proceedings First Sacramento-San Joaquin River Problems Conference, 1924.
*Bulletin No. 4—Proceedings Second Sacramento-San Joaquin River Problems Conference, and Water Supervisor's Report, 1924.
Bulletin No. 5—San Gabriel Investigation—Basic Data, 1923–1926.
Bulletin No. 6—San Gabriel Investigation—Basic Data, 1926–1928.
Bulletin No. 7—San Gabriel Investigation—Analysis and Conclusions, 1929.
*Biennial Report, Division of Water Rights, 1920–1922.
*Biennial Report, Division of Water Rights, 1922–1924.
Biennial Report, Division of Water Rights, 1924–1926.
Biennial Report, Division of Water Rights, 1926–1928.

DEPARTMENT OF ENGINEERING

*Bulletin No. 1—Cooperative Irrigation Investigations in California, 1912–1914.
*Bulletin No. 2—Irrigation Districts in California, 1887–1915.
Bulletin No. 3—Investigations of Economic Duty of Water for Alfalfa in Sacramento Valley, California, 1915.
*Bulletin No. 4—Preliminary Report on Conservation and Control of Flood Waters in Coachella Valley, California, 1917.
*Bulletin No. 5—Report on the Utilization of Mojave River for Irrigation in Victor Valley, California, 1918.
*Bulletin No. 6—California Irrigation District Laws, 1919 (now obsolete).
Bulletin No. 7—Use of water from Kings River, California, 1918.
*Bulletin No. 8—Flood Problems of the Calaveras River, 1919.
Bulletin No. 9—Water Resources of Kern River and Adjacent Streams and Their Utilization, 1920.
*Biennial Report, Department of Engineering, 1907–1908.
*Biennial Report, Department of Engineering, 1908–1910.
*Biennial Report, Department of Engineering, 1910–1912.
*Biennial Report, Department of Engineering, 1912–1914.
*Biennial Report, Department of Engineering, 1914–1916.
*Biennial Report, Department of Engineering, 1916–1918.
*Biennial Report, Department of Engineering, 1918–1920.

* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

DIVISION OF WATER RESOURCES

Including Reports of the Former Division of Engineering and Irrigation

*Bulletin No. 1—California Irrigation District Laws, 1921 (now obsolete).
*Bulletin No. 2—Formation of Irrigation Districts, Issuance of Bonds, etc., 1922.
Bulletin No. 3—Water Resources of Tulare County and Their Utilization, 1922.
Bulletin No. 4—Water Resources of California, 1923.
Bulletin No. 5—Flow in California Streams, 1923.
Bulletin No. 6—Irrigation Requirements of California Lands, 1923.
*Bulletin No. 7—California Irrigation District Laws, 1923 (now obsolete).
*Bulletin No. 8—Cost of Water to Irrigators in California, 1925.
Bulletin No. 9—Supplemental Report on Water Resources of California, 1925.
*Bulletin No. 10—California Irrigation District Laws, 1925 (now obsolete).
Bulletin No. 11—Ground Water Resources of Southern San Joaquin Valley, 1927.
Bulletin No. 12—Summary Report on the Water Resources of California and a Coordinated Plan for Their Development, 1927.
Bulletin No. 13—The Development of the Upper Sacramento River, containing U. S. R. S. Cooperative Report on Iron Canyon Project, 1927.
Bulletin No. 14—The Control of Floods by Reservoirs, 1928.
*Bulletin No. 18—California Irrigation District Laws, 1927 (now obsolete).
Bulletin No. 18—California Irrigation District Laws, 1929 Revision.
Bulletin No. 19—Santa Ana Investigation, Flood Control and Conservation (with packet of maps), 1928.
Bulletin No. 20—Kennett Reservoir Development, an Analysis of Methods and Extent of Financing by Electric Power Revenue, 1929.
*Bulletin No. 21—Irrigation Districts in California, 1929.
Bulletin No. 21-A—Report on Irrigation Districts in California for the Year 1929, 1930.
Bulletin No. 22—Report on Salt Water Barrier (two volumes), 1929.
Bulletin No. 23—Report of Sacramento-San Joaquin Water Supervisor, 1924–1928.
Bulletin No. 24—A Proposed Major Development on American River, 1929.
Bulletin No. 32—South Coastal Basin, a Cooperative Symposium, 1930.
Biennial Report, Division of Engineering and Irrigation, 1920–1922.
Biennial Report, Division of Engineering and Irrigation, 1922–1924.
Biennial Report, Division of Engineering and Irrigation, 1924–1926.

COOPERATIVE AND MISCELLANEOUS REPORTS

*Report of the Conservation Commission of California, 1912.
*Irrigation Resources of California and Their Utilization (Bul. 254, Office of Exp. U. S. D. A.) 1913.
*Report, State Water Problems Conference, November 25, 1916.
*Report on Pit River Basin, April, 1915.
*Report on Lower Pit River Project, July, 1915.
*Report on Iron Canyon Project, 1914.
*Report on Iron Canyon Project, California, May, 1920.
*Sacramento Flood Control Project (Revised Plans), 1925.
Report of Commission Appointed to Investigate Causes Leading to the Failure of St. Francis Dam, 1928.
Report of the Joint Committee of the Senate and Assembly Dealing With the Water Problems of the State, 1929.

PAMPHLETS

Rules and Regulations Governing the Supervision of Dams in California, 1929.
Water Commission Act with Latest Amendments Thereto, 1929.
Rules and Regulations Governing the Appropriation of Water in California, 1929.
Rules and Regulations Governing the Determination of Rights to Use of Water in Accordance with the Water Commission Act, 1925.
Tables of Discharge for Parshall Measuring Flumes, 1928.
General Plans, Specifications and Bills of Material for Six and Nine Inch Parshall Measuring Flumes, 1930.

* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

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